STUDIES ON THE HYDROPHYTES OF LUCKNOW AND ENVIRONS
I. DISTRIBUTION AND HABIT, WITH A REFERENCE TO ECOLOGICAL CLASSIFICATION

By

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Introduction

Studies on the hydrophytes of India received scant attention till about 1935. The first comprehensive work was produced by Biswas and Calder (1937), which dealt with the hydrophytes of India and Burma. In the last two decades quite a good deal of work has been done in certain parts of India. A few workers who have presented useful data may be mentioned here ; Misra (1946), Mirashi (1954, 1. /;, Kachroo (1956), Patnaik and Patnaik (1956), Chavan and Sabnis (1961) ; and Seervani (1962). Subramanyam has published a volume (1962) which deals with the taxonomic features of aquatic plants.

The study of hydrophytes in Uttar Pradesh has been neglected. Duthie's flora of the Upper Gangetic Plain of which Lucknow is a part, gives only the systematic account of the flora, leaving the ecology untouched. Dudgeon (1920) while describing the ecology of the Gangetic Plain, gives only a short account of the hydrophytic vegetation. His studies are mainly focussed on the ecology of Allahabad. Kapoor (1962), in his paper "On the Botany of Lucknow District" gives a list of species growing there, with a brief description of the vegetation including the plants which are found in and around the lakes and pools. Patil (1963) gives a general idea of distribution and floristic composition of some of the species growing in Lucknow. Recently Balapure and Srivastava (1964) have published a book on the vegetation of Lucknow district which gives a general idea of the hydrophytes occurring there. The authors are unaware of any comprehensive work dealing directly with the ecology and distribution of the hydrophytes of Lucknow and environs.

In the present paper the authors have tried to give a comprehensive account of the ecology and distribution of aquatic and marsh plants of Lucknow and environs. One of us (P. C. Sharma) has visited, the area of study, a number of times during the years 1962-64, the results of this study are given below.

[1]

Locality

Lucknow (26·52N and 80·58E) is situated on both the sides of the river Gomti and is nearly in the centre of the Gangetic Plain and also the State of Uttar Pradesh. The mean height of the district from the sea level is about 110 meters. The area of our study is roughly 140 sq. Kilometers—about 12 Kilometers on each side of the city, proper.

Climatic Factors

The climate of this area is continental and shows three well marked seasons viz. rainy, winter and summer. The mean maximum temperature in winter is 23·4°C in the month of January (coldest month), while the mean maximum temperature in summer is 40·8°C in the month of May (hottest month). Mean minimum temperatures vary from 8·4°C (in January) to 27·7°C (in June), (Sharma, 1959).

Rains occur mostly in the months of June to October (= rainy season). There is a low rainfall in winter while very little or none in the summer months. The average annual rainfall is recorded at 953·2 mm. in 1958.

There is a strong hot dry north westerly wind in the summer months, locally known as 'loo', it makes the weather very dry ; due to its drying action and high temperature most of the plants perish.

All the above climatic factors highly effect the vegetation. The ponds and puddles get filled up during the rainy months. The water level starts receding in the beginning of winter and thus during winter months the ponds and pools show on their banks a green vegetation of wet meadow stage. Most of them dry up in the summer, leaving little or no indication of hydrophytic vegetation that once existed there.

Habitat

Lakes, ponds, puddles, ditches, nalas, drains, the river Gomti and its tributaries are the common sites of occurrence of the hydrophytes. Many of the lakes and ponds occur near the roads or at a short distance from them. For convenience we have divided the area of study into 7 smaller areas as shown in the map (fig. 1). Each of these areas has a number of situations where the hydrophytes grow. The areas are : (1) City area (2) Kukrail area (3) Ismailganj-Chinhat area (4) Terhi Pulia·Basaha area (5) Mahibullahpur-Madiyavan area (6) Telibagh-Bangla-bazar area and (7) Mawaiyya area.

Description of Habitat

1. *City area*—This area is not very rich in aquatic vegetation due to biotic factors. The area includes Khajuha Jheel in Aishbagh area, Martinere College tank, a few smaller puddles, nalas and the river Gomti as the chief habitats of hydrophytes. Moti Jheel in Aishbagh area is not very important in this respect because it is very poor in aquatic vegetation. The area around this Jheel is industrialised and due to accumulation of waste and oily industrial products its fertility has probably decreased and it has got a very few aquatic plants. Khajuha Jheel, being present near human habitations, is mainly used for the cultivation of *Trapa* and paddy crops. In addition to *Trapa*, there are a few water plants in wild state in this lake with *Eichhornia crassipes* as the dominant. Martinere College tank shows the abundance of the following submerged plants : *Hydrilla verticillata, Ceratophyllum demersum, Zanichellia palustris, Potamogeton pectinatus, P. crispus* and *P. nodosus*. On its banks there is a good growth of *Marsilea* sp. Common wetland plants which grow in abundance on the embankments of these ponds and puddles

[2]

are *Alternanthera sessilis, Eclipta prostrata, Cyperus* spp. *Ammania baccifera, Polygonum plebejum, Rumex dentatus, Coronopus didymus* and *Marsilea* sp.

The Gomti passes through the city creating low lying areas along its course ; these remain submerged during the rains and show wetland vegetation in winter. *Ranunculus sceleratus,* common here, is not evident in other areas. Alkaline areas show the growth of *Bacopa monniera. Polygonum glabrum* also grows profusely on the banks of the river. Plants which occur inside water are *Eichhornia crassipes, Vallisneria spiralis, Hydrilla verticillata, Potamogeton pectinatus, P. crispus* and *Ceratophyllum demersum.* These plants may have come due to floods or may have been taken by the nalas or rivulets that fall into the river.
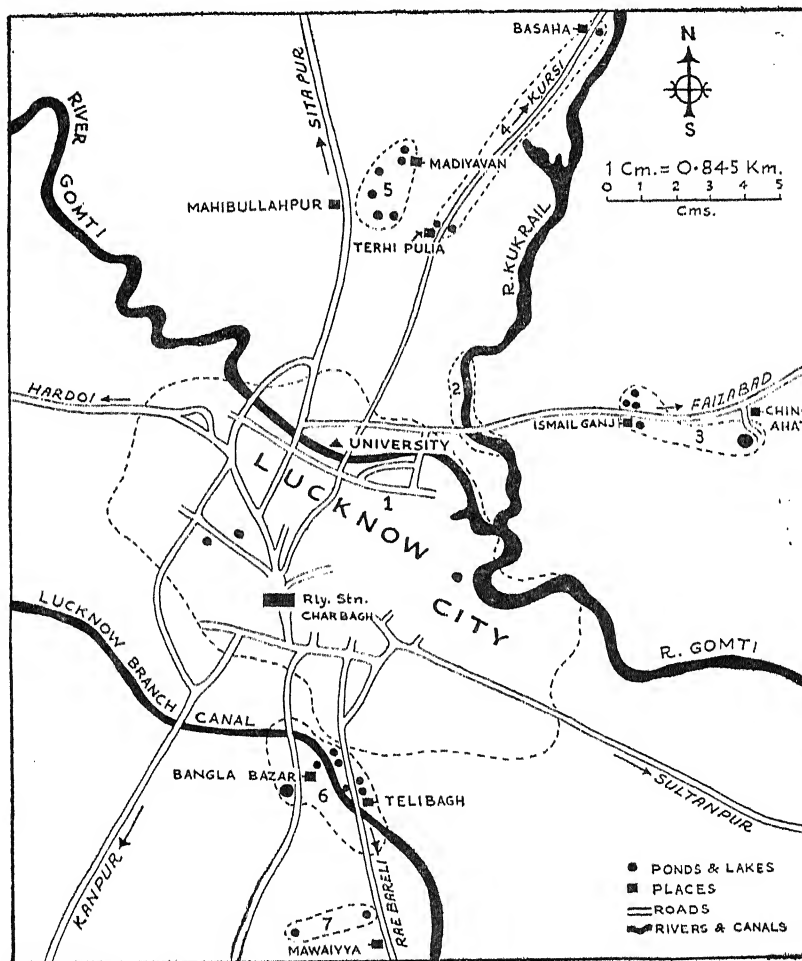
Fig. 1. A map of the locality showing the various habitats.

2. *Kukrail area*—The Kukrail nala or rivulet is a tributary of the river Gomti. The area near the Faizabad road bridge is fertile due to the deposition of

waste and excretory products. The rivulet has only a few water plants, amongst which *Sagittaria sagittifolia*, *Scirpus mucronatus* and *Zanichellia palustis*, growing here, are not common in other areas. An excellent growth of *Polygonum glabrum* has been observed on its banks. In muddy areas *Typha angustata* may also be ·seen. *Chara* sp. and *Nitella* sp. also occur sporadically.

3. *Ismailganj-Chinhat area*—There are a few important ponds near Ismail-ganj *viz*. Sotava tal. Bhojania tal, and Kamayya tal. These ponds are rich in aquatic flora and show a considerable number of plants during the rainy season and early winter months. Being located near the human habitation, ponds are used for the cultivation of *Trapa bispinosa* and paddy. when water dries up, the bottoms of these ponds show the growth of *Cyperus* spp. *Ammania baccifera*, *Gnaphalium pulvinatum*, *Polygonum plebejum*, *Phyla nodiflora* and *Alternanthera sessilis*. *Utricularia flexuosa* and *U. stellaris* have also been collected from these ponds. *U. flexuosa* shows a much restricted distribution.

Near Chinhat there is a big lake 'Kathauta tal'. The lake is about 3–4 meters deep and does not dry up even in the summer months ; although the water level goes considerably down. Flora of the lake is very rich and it is represented by about 50 species. The chief of them are *Eichhornia crassipes*, *Nymphaea* spp., *Nymphoides cristatum*, *Hydrilla verticillata*, *Pistia stratiotes* (these grow in slightly deeper water) ; *Nelumbo nucifera* grows towards the central deeper part and *Utricularia stellaris*, *U. flexuosa*, *Ipomoea aquatica*, *Vallisneria spiralis*, *Ottelia alismoides*, *Nechamandra alternifolia* and *Neptunia oleracea* grow in shallow water, near the banks of the lake. *Corchorus capsularis*, *Astercantha longifolia*, *Cyperus* spp., *Bacopa monniera*, *Dentella repens*, *Caesulia axillaris*, *Ammania baccifera* and *Polygonum plebejum* grow on the banks.

4. *Terhi Pulia-Basaha area*—This area includes 'Sagara' ponds present near Terhi Pulia and Basaha tal near Basaha and a few puddles here and there. The area is poor in aquatic as well as wet land vegetation. *Hygroryza aristata*, and *Pistia stratiotes* deserve mention in this locality.

5. *Mahibullahpur-Madiyavan area*—This area includes ponds like Jibida tal, Khotaya tal and Naboda tal. This area is rich in hydrophytic vegetation and shows a considerable number of aquatic as well as wetland species. These ponds are used for the cultivation of *Trapa bispinosa* in rainy and winter months. A good growth of *Typha angustata* has been observed on the muddy embankments of some ponds.

Ponds of this area are shallow and hence the area gets flooded during the rains. Water level recedes during the early winter exposing a large area of wet marshy soil. The area later gets covered by a large number of wetland plants viz. *Ammania* spp., *Hygrophila polysperma*, *Caesulia axillaris*, *Rumex dentatuts*, *Gnaphalium pulvinatum*, *Mazus japonicus*, *Veronica anagallis* and *Cyperus* spp. *Tenagocharis latifolia* collected from a nala near Madiyavan is a newly recorded species from Lucknow district. This plant has a very restricted distribution.

6. *Telibagh-Banglabazar area*—Most of the ponds and lakes are annuals which dry up during the winters or summers. A few ponds *viz*. Lala Hargovind ka tal, Bhandari tal and a few small puddles are situated on the embankments of Rae Bareli road near Telibagh. Of these 'Lala Hargovind ka tal' is the deepest and it has some water even during the summer. Lachchhi tal, Debikhera tal and few other ponds and puddles are present near the embankments of Lucknow branch canal near its 110th stone. In addition to these, there is a lake between Banglabazar and Qila Mohammadinagar. The lake is shallow but quite extensive.

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It nearly dries up during summer. The lake is not very rich in hydrophytic vegetation and is used mostly for the cultivation of paddy. The water appears to be entirely covered by rice plants and *Eleocharis plantaginea* in rainy months. The canal, present in this area, itself has hardly any aquatic plants due to the fast flow of the water but the seepages from it are ideal for the growth of hydrophytic vegetation. Some seepages occasionally develop into puddles. Soil of the area being alkaline, the vegetation is not very rich, though, some tolerent species show good growth e.g. *Typha angustata, Bacopa monniera, Eclipta prostrata, Phyla nodiflora, Alternanthera sessilis, Fimbristylis miliacea, Fimbristylis schoenoides, Scirpus supinus,* and *Cyperus* spp.

7. *Mawaiyya area*—This locality shows a vegetation almost identical to Telibagh area. This area includes a lake near Mawaiyya and a few ponds. *Eichhornia crassipes* is the dominating aquatic species of this area. *Hygroryza aristata,* not evident in its neighbouring area (Telibagh-Banglabazar area), has been observed in this locality.

A few hydrophytes recorded by Kapoor (1962) or Balapure and Srivastava (1964) escaped being noticed by us probably because we took only a part of the district into consideration. They are *Malachra capitata* Linn ; *Jussiaea perennis* (Linn.) Brenan., *Eleocharis dulcis* Trin., *Scirpus articulatus* Linn ; *Nymphoides indicum* Thw., *Limnophila heterophylla* Benth., *L. indica* (L.) Druce., *Polygonum stagninum* Buch-Ham., *Enhydra fluctuans* Lour. *Cyperus esculentus* Linn., *Lemna oligorrhiza* Kurz., and *Dopatrium junceum* (Roxb.) Buch-Ham.

Ecological Classification

The hydrophytes of this area may be classified under the following life forms ; depending on their relations with soil, water and air.

A. Floating hydrophytes—Three types of plants are included in this category ; they are :

(1) *Free floating on the surface of water*—These are the plants which have no contact with soil. They float on the surface of water and are in contact with air and water only e.g. *Spirodela polyrhiza, Wolffia arrhiza Pistia stratiotes, Eichhornia crassipes, Hygroryza aristata, Trapa bispinosa* and *Azolla pinnata.*

(2) *Attached hydrophytes with floating shoots*—These hydrophytes are attached to the muddy floor by their roots, but their shoots come out and float on the surface of water. These plants are thus concerned with soil and water as well as with air e.g. *Jussiaea repens, Ipomoea acquatica* and *Neptunia oleracea.*

(3) *Attached hydrophytes with floating leaves*—These are the plants which are attached to the muddy floor, the leaves float on the surface of water ; while the stem (mostly rhizome) remain under water in contact with soil and water *viz.* in *Nymphaea* spp. and *Nymphoides cristatum* all the leaves float while in *Potamogeton crispus* and *Otellia alismoides* some leaves float on the water surface and others are submerged.

B. Submerged hydrophytes—Hydrophytes which always remain under water surface are kept here ; these may be classified into two subgroups.

(1) *Suspended submerged hydrophytes*—Plants which always remain submerged in water without any contact with soil *i.e.* they are not rooted

to the soil, are placed here. The flowers may or may not come above the water level *e.g. Ceratophyllum demersum* and *Utricularia* spp.

(2) *Attached submerged hydrophytes*—Plants which are in contact with soil and water only. The vegetative portion remains completely submerged in water, while the flowers may come out of the water surface, *e.g. Hydrilla verticillata, Potamogeton pectinatus, Nechamandra alternifolia, Zanichellia palustris, Vallisneria spiralis, Chara* sp. and *Nitella* sp.

C. *Emerged hydrophytes*—Plants are attached to the soil covered with water, but most of their vegetative parts come out of the water surface. These may be further sub-divided into—

(1) *Purely aquatic plants*—Plants attached to the soil covered with water, being unable to survive in drier soils *e.g. Sagittaria sagittifolia* and *Scirpus mucronatus.*

(2) *Amphibious plants*—Plants, which usually grow in soil covered with water but can also survive in marshy or drier soils, *viz. Aeschynomene aspera, A. indica, Sesbania bispinosa, Polygonum glabrum.*

D. *Wetland hydrophytes*—Plants rooted to the soil usually saturated with water, which may also survive in drier conditions in the later part of their life cycle. This group includes a large number of species growing within this area like *Eclipta prostrata, Phyla nodiflora, Alternanthera sessilis, A. paronychioides* St. Hill. *Polygonum glabrum* and *Polygonum plebejum* grow throughout the year or for most of the year ; *Commelina benghalensis, C. obliqua, Astercantha longifolia* and *Corchorus capsularis* are common throughout the rainy season ; while *Bacopa monniera* is found during rains as well as in winter. *Veronica anagallis, Glinus oppositifolius, G. lotoides, Gnaphalium pulvinatum, Caesulia axillaris* and *Ranunculus sceleratus* grow in winter season only.

TABLE I

Showing taxonomic enumeration, habit, flowering period and distribution of the hydrophytic species

Name of the Family and species	Habit	Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
Isoetaceae									
1. *Isoetes coromandelina* Linn.	C_2	...	—	—	—	—	—	—	—
Marsileaceae									
2. *Marsilea* sp. (Susni Shak.)	C_2	...	+	+	+	+	+	+	+
Salviniaceae									
3. *Azolla pinnata* R.Br.	A_1	...	+	+	+	+	+	+	+
Ranunculaceae									
4. *Ranunculus sceleratus* Linn. (Sita Sarson ; Jaldhania)	D	Feb.—Mar.	+	—	—	—	—	—	—

Name of the Family and species Habit		Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
Nymphaeaceae									
5. *Nelumbo nucifera* Gaertn. (Kamal)	C_1	Mar.—Aug.	–	–	+	–	–	+	–
6. *Nymphaea nouchali* Burm. f. (Kokabeli)	A_3	Jul.—Oct.	+	–	+	+	+	+	+
7. *N. stellata* Willd. (Kumudini)	A_3	Jul.—Oct.	+	–	+	+	+	+	+
Cruciferae									
8. *Coronopus didymus* Sm.	D	Feb.—Mar.	+	+	+	–	+	–	–
Malvaceae									
9. *Malachra capitata* Linn.									
Tiliaceae									
10. *Corchorus capsularis* Linn. (Jute ; narcha, kalasaka)	D	R. S.	–	–	+	–	–	–	–
Leguminosae									
11. *Aeschynomene aspera* Linn. (Sola or Shola)	C_2	R. S.	–	–	+	–	+	–	–
12. *A. indica* Linn. (Tigajiluga)	C_2	R. S.	–	–	+	–	+	–	–
13. *Crotalaria medicaginea* Lamk. (Gulabi)	D	R. S.	–	–	–	–	+	–	–
14. *Neptunia oleracea* Lour. (Pani-lajak)	A_2	Sep.—Jan.	–	–	+	–	–	–	–
15. *Sesbania bispinosa* W.F. Wight. (Jayanti)	C_2	R. S.	–	–	+	–	+	–	–
Rosaceae									
16. *Potentilla supina* Linn.	D	C. S.	+	+	+	–	+	–	+
Lythraceae									
17. *Ammania baccifera* Linn. (Dad-mari)	D	C. S.	+	+	+	+	+	+	+
18. *Ammania salicifolia* Monti.	D	Oct.—Dec.	–	+	+	–	+	–	–
Onagraceae									
19. *Jussiaea perennis* (Linn.) Brenan.		Mostly in R. S.							
20. *Jussiaea repens* Linn.	A_2		+	–	+	+	+	+	+
21. *J. suffruticosa* Linn. (Lal-bulunga)	D	R. S.	–	–	+	–	–	–	–
22. *Ludwigia parviflora* Roxb. (Bhalava auga)	D	R. S.	–	+	+	–	–	–	–

Name of the Family and species	Habit	Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
23. *Trapa bispinosa* Roxb. (Singhara)	A_1	R. S.	+	—	+	+	+	+	+
Ficoideae									
24. *Gisekia pharnaceoides* Linn.	D	C. S.	+	+	—	—	+	—	+
25. *Glinus lotoides* Linn.	D	C. S.	+	+	—	—	+	—	+
26. *Glinus oppositifolius* A. DC. (Ghima Sak.)	D	C. S.	+	+	—	—	+	—	—
27. *Molluga pentaphylla* Linn.	D	C. S.	+	+	—	—	—	—	—
Rubiaceae									
28. *Dentella repens* Forst.	D	C. S.	—	—	+	—	—	—	—
Compositae									
29. *Caesulia axillaris* Roxb.	D	C. S.	—	—	+	+	+	+	+
30. *Eclipta prostrata* Linn. (Bhringaraja)	C_2	Most of the year	+	+	+	+	+	+	+
31. *Enhydra fluctuans* Lour.									
32. *Gnaphalium pulvinatum* Del.	D	C. S.	+	+	+	+	+	+	+
33. *Grangea maderaspatana* Poir. (Mustaru)	D	Greater part of the year	+	+	—	—	—	—	—
34. *Sphaeranthus indicus* Linn. (Mundi)	D	C. S.	+	+	+	—	+	—	—
35. *Xanthium strumarium* Linn. (Ban-okra)	D	Most of the year	+	+	+	—	—	—	—
Campanulaceae									
36. *Campanula canescens* Wall.	D	Feb.—Mar.	+	+	—	—	+	—	—
37. *Wahlenbergia gracilis* Schrad.	D	Feb.—Mar.	—	—	—	—	—	—	—
Primulaceae									
38. *Androsace saxifragaefolia* Bunge	D	Feb.—Mar.	—	—	—	—	—	—	—
Gentianaceae									
39. *Nymphoides cristatum* Ktze. (Cumuda)	A_3	Mar.—Jun.	—	—	+	—	—	+	+
40. *N. indicum.* Thw									
Hydrophyllaceae									
41. *Hydrolea zeylanica* Vahl. (Langali)	D	Oct.—Dec.	—	—	—	—	+	—	—
Convolvulaceae									
42. *Impomoea aquatica* Forsk. (Nari or Keramua)	A_2	C. S.	+	—	+	+	+	+	+

Name of the Family and species	Habit	Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
Scrophulariaceae									
43. *Bacopa monniera* Pennell. (Nira-Brahmi.)	D	Sep.—Nov.	−	+	+	−	−	+	+
44. *Dopatrium junceum* (Roxb.) Buch.-Ham.									
45. *Limnophila heterophylla* Benth.									
46. *L. indica* (L.) Druce.									
47. *Lindernia crustacea* Muell.	D	R. S. & C. S.	+	+	−	−	−	−	−
48. *Mazus japonicus* Ktze.	D	C. S.	+	+	+	−	+	−	−
49. *Veronica anagallis* Linn.	D	C. S.	+	+	+	−	+	−	−
Lentibulariaceae									
50. *Utricularia flexuosa* Vahl.	B_1	R. S. & C. S.	−	−	+	−	−	−	−
51. *Utricularia stellaris* Linn. f.	B_1	R. S.	−	−	+	−	+	+	+
Acanthaceae									
52. *Astercantha longifolia* (Linn.) Nees. (Kokilaksha or Talimakhana)	D	C. S.	−	−	+	+	+	+	+
53. *Hygrophila polysperma* T. Anders.	D	R. S.	−	−	+	+	+	−	−
Verbenaceae									
54. *Phyla nodiflora* Green. (Ludra)	D	Most of the year	+	+	+	+	+	+	+
Amaranthaceae									
55. *Alternanthera paronychioides* St. Hill.	D	R. S.	+	+	+	−	−	−	−
56. *Alternanthera sessilia* R.Br. (Mokunuwanna)	D	Most of the year	+	+	+	+	+	+	+
Polygonaceae									
57. *Polygonum glabrum* Willd. (Sauriasak, jioti)	D	C. S.	+	+	+	+	−	−	−
58. *P. plebejum* R.Br. (Raniphul)	D	Cold and Summer S.	+	+	+	+	+	+	+
59. *P. stagninum* Buch.-Ham.									
60. *Rumex dentatus*	D	C. S.	+	+	+	+	+	+	+
Ceratophyllaceae									
61. *Ceratophyllum demersum* Linn.	B_1		+	+	+	+	+	+	+
Hydrocharitaceae									
62. *Hydrilla verticillata* (L. f.) Royle (Jhangi Kureli)	B_2	C. S.	+	+	+	+	+	+	+

Name of the Family and species	Habit	Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
63. *Nechamandra alternifolia* (Roxb.) Thw.	B_2	C. S.	–	–	+	–	–	–	–
64. *Ottelia alismoides* Pers.	P_2	Cold and Summer S.	–	–	+	–	–	–	–
65. *Vallisneria spirallis* Linn. (Punastsu)	B_2	C. S.	+	–	+	–	–	–	–
Pontederiaceae									
66. *Eichhornia crassipes* Solms. (Kachuri pana, or Jalakumbhi)	A_1	Rainy and Cold S.	+	+	+	+	+	+	+
67. *Monochoria vaginalis* Presl. ex Kunth.	A_3	...	–	–	–	–	–	–	–
Commelinaceae									
68. *Commelina benghalensis* Linn. (Kanchura)	D	R. S.	+	+	+	+	+	+	+
69. *C. obliqua* Buch-Ham. (Kanjura)	D	R. S.	–	+	+	+	–	–	–
70. *Murdannia nudiflora* Brenan.	D	Sep.—Nov.	+	+	+	–	–	–	–
Typhaceae									
71. *Typha angustata* Bory. et Chaub (Pater)	C_2	C. S.	–	+	–	–	+	+	–
Araceae									
72. *Pistia stratiotes* Linn. (Takapana)	A_1	Summer S.	–	–	+	+	–	–	–
Lemnaceae									
73. *Lemna oligorrhiza* Kurz.									
74. *Spirodela polyrhiza* (L.) Schleid.	A_1	C. S.	+	+	+	+	+	+	+
75. *Wolffia arrhiza* Wimm.	A_1	...	+	–	+	–	–	–	–
Alismaceae									
76. *Sagittara guayanensis* H. B. K.	C_1	C. S.	–	–	+	–	–	–	–
77. *S. sagittifolia* Linn. (Chota-kut)	C_1	C. S.	–	+	+	–	–	–	–
Butomaceae									
78. *Tenagocharis latifolia* (D. Don) Buchen.	D	C. S.	–	–	–	–	+	–	–
Aponogetonaceae									
79. *Aponogeton crispum* Thunb.	B_2	R. S.	+	–	+	–	+	–	–
80. *A. natans* (L.) Engl. & Krause. (Ghechu)	C_2	R. S.	+	–	+	–	+	+	+

Name of the Family and species	Habit	Flowering period	Distribution of the species						
			1	2	3	4	5	6	7
Potamogetonaceae									
81. *Potamogeton crispus* Linn. (Sewal)	A_3	Mar.—Apr.	+	+	+	–	+	+	+
82. *P. pectinatus* Linn.	B_2	Jan.—Mar.	+	+	+	–	–	–	–
83. *P. nodosus* Poir.	B_2	Feb.—Mar.	+	–	–	–	–	–	–
Naiadaceae									
84. *Zanichellia palustris* Linn.	B_2	C. S.	+	+	+	–	–	–	–
Cyperaceae									
85. *Cyperus aristatus* Rottb.	C_2	...	+	+	+	–	+	–	+
86. *C. difformis* Linn.	C_2	R. S.	+	+	+	–	+	–	+
87. *C. digitatus* Roxb.	C_2	R. S.	+	–	+	–	+	+	–
88. *C. distans* Linn.	C_2	C. S.	–	+	+	–	+	–	–
89. *C. esculentus* Linn.									
90. *C. iria* Linn. (Bura-chucha)	D	C. S.	+	+	+	+	+	+	+
91. *C. rotundus* Linn. (Motha)	D	Most of the year	+	+	+	+	+	+	+
92. *Cyperus* sp.	C_2	...	–	+	+	–	+	–	–
93. *Eleocharis dulcis* Trin.									
94. *Eleocharis plantaginea* R.Br. (Narai)	C_1	C. S.	–	+	+	+	+	+	+
95. *Fimbristylis miliacea* Vahl.	D	R. S.	–	–	+	–	–	+	–
96. *F. schoenoides* Vahl.	D	R. S.	–	–	–	–	–	+	–
97. *Scirpus articulatus* Linn.									
98. *S. mucronatus* Linn.	C_1	Most of the year	–	+	–	–	–	–	–
99. *S. supinus* Linn.	D	Most of the year	+	–	–	↖	–	+	–
Gramineae									
100. *Echinochloa* sp.	D	C. S.	+	+	+	–	–	+	+
101. *Hygroryza aristata* Nees. (Jangli dal.)	A_1	C. S.	–	–	–	+	+	–	+
102. *Oryza perennis* Moench.	C_2	R. S.	–	–	+	–	+	+	+
103. *Paspalidium geminatum* (Forsk.) Stapf.	C_2	R. and C. S.	+	–	–	–	–	+	+

A_1, Free floating on the surface of water ; A_2, Attached with floating shoots ; A_3, Attached with floating leaves ; B_1, Suspended submerged ; B_2, Attached submerged ; C_1, Purely aquatic emerged ; C_2, Amphibious emerged ; D, Wet land plant ; C. S., cold season ; R. S. rainy season.

+ = present, – = absent.
1 = City area ; 2 = Kukrail area ; 3 = Ismailganj-Chinhat area ;
4 = Terhi-pulia-Basaha area ; 5 = Mahibullahpur-Madiyavan area ;
6 = Telibagh-Bangala Bazar area ; and 7 = Mawaiyya area.

Discussion

The ponds, puddles and lakes of this area as also the river Gomti and its tributaries become flooded during the rains and show only a small number of aquatic species on their surface or near the banks ; these are *Eichhornia crassipes, Ipomoea aquatica, Nymphaea* spp., *Spirodela polyrhiza* and *Trapa bispinosa* etc.

When, after the rains, water starts receding, the constituents of wet land vegetation e.g. *Cyperus* spp., *Caesulia axillaris, Polygonum plebejum, Phyla nodiflora, Alternanthera sessilis, Gnaphalium pulvinatum, Rumex dentatus, Veronica anagallis, Sphaeranthus indicus* and *Potentilla supina* make their appearance. The rainy season aquatics viz. *Nymphaea* spp., *Nymphoides* spp., *Nelumbo nucifera* and *Ipomoea aquatica* are replaced by submerged winter plants like *Hydrilla verticillata, Potamogeton* spp., *Zanichellia palustris* and *Nechamandra alternifolia* etc. The Gomti banks have a carpet of *Ranunculus sceleratus*, an appreciable growth of which has been observed by us near the military farm during winters. Many of the submerged and emerged species, not seen during rains, become evident then.

The aquatic flora of the perennial ponds is characterised by the occurrence of the species like *Nelumbo nucifera, Nymphoides cristatum, N. indicum* and *Trapa bispinosa*, etc. *Hydrilla verticillata* not seen during rains becomes evident in winter.

Wet land vegetation of Usar soil is characterised by the preponderance of *Bacopa monniera, Scirpus supinus, Fimbristylis schoenoides, F. miliaceae, Cyperus difformis Typha angustata.*

The most common aquatic plants of the locality are *Eichhornia crassipes, Trapa bispinosa, Nymphaea* spp., *Ceratophyllum demersum Spirodela polyrhiza* and *Hydrilla verticillata*. Due to gregarious growth of *Eichhornia crassipes* throughout the area as well as due to the cultivation of *Trapa* and paddy crops on a large scale, the natural aquatic flora of this locality is becoming poor. A primitive species like *Raunculus sceleratus* not recorded in Central Indian region is represented here.

Present communication includes 103 species of vascular plants. On the basis of our investigations the following taxonomic data could be given.

	Families	Genera	Species
Pteridophyta			
Isoetales	1	1	1
Hydropteridineae	2	2	2
Angiosperms			
Dicotyledons	24	46	57
Monocotyledons	13	26	43
Total	40	75	103
% $\frac{\text{1-Cot.}}{\text{2-Cot.}}$	1 : 1·8	1 : 1·8	1 : 1·3

The total number of hydrophytic species encountered here is greater as compared to the number of hydrophytes enlisted from the other parts of the country. Mirashi (1954, 1957) reported 53 and 64 hydrophytic species including Pteriodphytes from Nagpur and Umred, respectively. Chavan and Sabnis (1961) reported 58 hydrophytic species from Baroda. Seervani (1962) reported 88 species (including the plants of dried banks) from Jabalpur. We have recorded 103 hydrophytic species. Hence when we compare the total number of species

growing in Umred and Jabalpur (Central Indian region) with that of Lucknow and environs (a part of Upper Gangetic Plain), the ratio comes to about 1 : 1·7 and 1 : 1·2 respectively.

The distribution of the hydrophytes is quite interesting. On the basis of the table 1 given in the text we find that Ismailganj-Chinhat area is the richest among all the areas, its hydrophytic vegetation is represented by about 65 species.

Four species of the total hydrophytes described here, however, do not actually occur in the area of our study, but are recorded from neighbouring places, three of which, *Isoetes coromandelina, Wahlenbergia gracilis* and *Androsace saxifragaefolia* were collected from Babaganj (near Itaunja railway station), while the fourth one, *Monochoria vaginalis* was found growing near Mohanlalganj.

Three species of hydrophytes *Tenagocharis latifolia* (D. Don.) Buchen., *Androsace saxifragaefolia* Bunge and *Hydrolea zeylanica* Vahl. are new records from the district. (Sharma 1964). Occurrence of *Hydrolea zeylanica* Vahl. has been recorded also by Balapure and Srivastava (1964).

The ecological classification given here is based on the relation that the plant has with soil, water and air. We have emended Mirashi's (1957) scheme and have tried to place the plants in more clear and definite categories. The floating hydrophytes have, therefore, been placed in three categories—(1) free floating hydrophytes, (2) attached hydrophytes with floating shoots and (3) attached hydrophytes with floating leaves only. Mirashi placed categories (1) and (2) under a single heading and called them 'floating hydrophytes'. Cases like *Ipomoea aquatica* and *Jussiaea repens*, etc. (attached plants with floating shoots) necessitated the creation of a separate category to accommodate plants with only one character. Thus there are two categories (1) and (2). A third category (3) includes 'attached hydrophytes with floating leaves only'. It goes with the former two as it does not seem proper to exclude the plants with floating leaves only, separate from plants with floating shoots, as the leaves form the major vegetative part of the shoot, e.g. *Nymphaea* and *Nymphoides* have only one type of leaf which floats on the surface of water and constitutes the major vegetative part of the plants. Mirashi kept this category quite separate from floating hydrophytes. He placed the suspended submerged hydrophytes and attached submerged hydrophytes under quite separate categories. We have kept both the categories—(1) suspended submerged and (2) attached submerged hydrophytes—under a single group—submerged hydrophytes'—as both these categories include plants which have their entire vegetative parts covered by water. Emerged hydrophytes include two categories—(1) purely aquatic plants, including the forms that grow in water with atleast their leaves coming out above the water surface ; they are, however, unable to grow outside water and (2) amphibious plants, including such plants which grow in water and are also able to adapt themselves to an environment having low percentage of water *i.e.* moist soil. Mirashi placed the above two categories separately. The last group—'wetland hydrophytes'—includes the plants growing in the soil rich in water content—a group similar to that described by Mirashi.

Summary

1. The area of our study has been divided into seven smallar units for convenience and more intensive study.

2. Description of the lakes, ponds, puddles, ditches, the river Gomti and its tributaries, with a short account of hydrophytic vegetation met within these habitats, is given.

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3. An ecological classification of plants based on the interrelations of plants with soil, water and air is given.
4. A table showing distribution, habit and flowering period of the aquatic and wetland plants occurring within the area is given.
5. Three species have been newly recorded from Lucknow district during the course of this study.
6. A map showing the area of study is given.

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BIOLOGICAL SPECTRUM OF LUCKNOW FLORA

By

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Introduction

Raunkiaer (1934, 1937) proposed a classification of plants into several Life-Forms on the basis of adaptation of the plants to survive the unfavourable seasons. Special emphasis was laid on the method of protection of buds during unfavourable conditions, on the survival of which depended the further existence of an individual. This system also takes into consideration the size and habit of the plants. He believed that the plant climate may be investigated through the critical approach to the biostatistical study of Life-Forms of an area.

Such type of studies have received scant attention in India. Borgesen (1929) studied the vegetation at Dwarka and also produced a Biological Spectrum. Bharucha and Ferreira (1941) made a study of the Biological Spectrum of Madras, Matheran and Mahabaleshwar which supported the Raunkiaer's hypothesis. Recently Lakshmanan (1962) investigated the Biological Spectrum of Vihar-lake forest and concluded that his studies do not support the Raunkiaer's hypothesis.

Dudgeon (1920) published a comprehensive account on the ecology of Upper Gangetic Plain, concluding that the vegetation of Upper Gangetic Plain, where annuals dominate at present, would have been in thorn scrub stage (= phanero-phytic) if it would have not been disturbed. Srivastava (1944) made a study of the flora of Allahabad ; published the Biological Spectrum of Allahabad Flora and concluded that the percentage of Therophytes is highest in that locality. Anderson (1859) was the first to publish a paper on the Flora of Lucknow, which has later on been reinvestigated by Kapoor (1962), Patil (1963) and Balapure and Srivastava (1964). Kapoor recorded 914 species of cultivated and wild flowering plants (including 5 cultivated Gymnospermous species) from Lucknow district. We have included only 560 species in the present communication, as the rest of the species, except few which could not be clearly demarcated into Life-Forms, are cultivated and may not be regarded as the constituents of the natural vegetation. Although the vegetation of this locality is subjected to biotic factors, we have tried to exclude the cultivated species in this study.

For the present investigation help was also taken from the works of Bor (1940), Brandis (1911), Duthie (1888 and 1903·29), Haines (1921), Hooker (1872–97).

PHYSICAL FEATURES

Topography

The district of Lucknow lies between the parallels 26° 30′ and 27° 10′ N. and 80° 31′ and 81° 13′ E. Its height above sea level is about 110 meters. It is situated in the central region of the Upper Gangetic Plain. There are

numerous lakes and ponds in the district, most of which dry up during the summer months. The soil ranges between clay to sandy clay and sand. Patches of Usar soil, and beds of soil and kankar are occasionally also met with.

Climate

Rainfall. The total average rainfall for Lucknow in 1958 has been recorded at 953·2 mm. (Sharma 1959). About 92% of the total rainfall occurs from mid-June to the beginning of October (rainy season). Winter (November to February) and summer (March—May) seasons receive only 5 and 3 percent rainfall respectively. This periodicity of rainfall greatly effects the soil moisture and relative humidity.
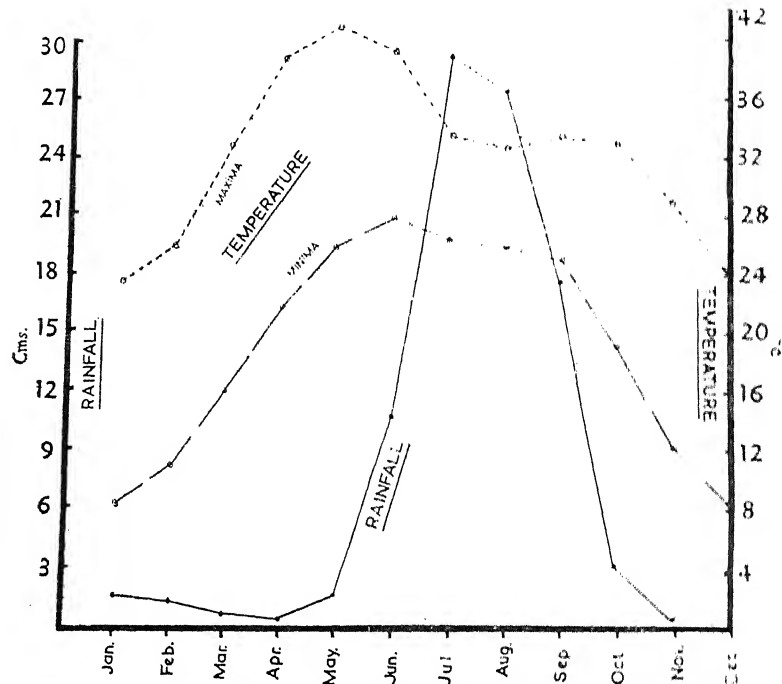
Fig. 1. Hydrotherm figure.

Temperature. Temperature is one of the most important factors in making the climate periodic and in creating the conditions of drought. There is a great range between the winter and summer temperatures (Table I).

Humidity. Relative humidity depends on the temperature and rainfall. It is maximum during July and August when there is maximum rainfall, and minimum in summer when the rainfall is very low and the temperature is very high.

Light intensity. During rainy season the atmosphere is mostly cloudy and thus there is low insolation, while in winter and summer seasons atmosphere is mostly fair, there are no clouds ; hence the insolation is high. The light intensity may however, below in winter on account of the southern sun, although atmospheric dust of the summer considerably cuts it down. It seems to be much intense during summer when both the temperature and the light intensity reach their maximum.

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*TABLE 1

Months	Average rainfall in mm.	Temperature in 0°C Mean Maximum	Temperature in 0°C Mean Minimum	Relative humidity %	Wind movement Direction	Wind movement Velocity in miles per hr.
January	17·6	23·4	8·4	64	NW	1·3
February	15·5	25·9	10·8	57	NW	1·7
March	8·4	32·7	15·9	38	NW	2·3
April	5·3	38·6	21·6	29	NW	2·4
May	16·5	40·8	25·8	37	NW	2·5
June	107·0	39·0	27·7	57·5	NW	2·6
July	289·0	33·6	26·4	78·5	SE	2·2
August	273·0	32·6	25·9	81·5	SE	1·9
September	176·1	33·4	24·8	76·5	SE	1·7
October	32·2	33·1	19·2	65·0	SE	1·1
November	4·8	28·9	12·3	62·5	NW	0·9
December	7·8	24·4	8·5	67·0	NW	0·1

NW=North-westerly.　SE = South-easterly.
*The climatic data have been taken from District Gazetteer. (*See* Sharma 1959).

TABLE 2

Biological Spectrum of Lucknow and some other regions.

Regions	No. of species	The percentage distribution of the species among the Life-Forms L	E & S	MM	M	N	Ch	H	Cr	Th
Normal	400	–	4	6	17	20	9	27	4	13
Death Valley California	294	–	3	–	2	21	7	18	7	42
Libyan desert	194	–	–	–	3	9	21	20	5	42
Tripoli	369	–	–	0·3	–	16	13	19	11	51
Allahabad	628	3·1	2·7	3	17·6	11·6	9·2	3·4	7·8	41·6
Lucknow	560	3·4	1·9	4·4	4·6	11·5	3·3	10·2	8·5	52·2

L=Lianas, S=Succulents, E=Epiphytes,
MM=Meso and mega phanerophytes, M=Microphanerophytes,
N=Nanophanerophytes, Ch=Chamaephytes, H=Hemicryptophytes,
Cr=Cryptophytes, Th=Therophytes.

Wind movement. In rainy season winds are south-easterly; while direction changes to north-westerly during winters though with reduced velocity. During summers velocity of north-westerly winds increases and it is converted into "loo"; the temperature also reaches its peak. High wind velocity may bring down temperature in the summer heat by mixing up air.
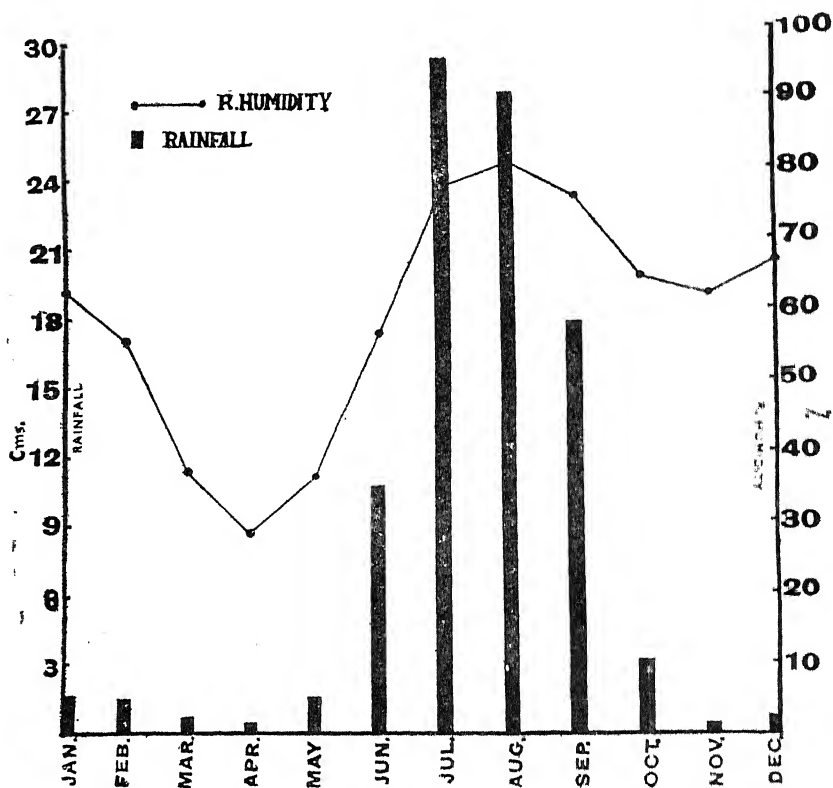

Fig. 2. Graph showing annual rainfall and humidity.

Hydrotherm Figure

The hydrotherm figure (fig. 1) is obtained by plotting the data of rainfall and temperature in the same graph. Data regarding the humidity and the rainfall have also been plotted together in a separate graph (fig. 2). From figs. 1 and 2, it is clear that there are three well pronounced seasons similar to that described for Allahabad by Srivastava (1944).

(1) The rainy season (mid-June to mid-October) is characterised by high rainfall, high temperature and humidity and low insolation.

(2) The winter season (November to February) is characterised by low rainfall and temperature, and high humidity and insolation.

(3) The summer season (March—May) is characterised by low rainfall and humidity, and high temperature and insolation.

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Biological Spectrum

Lucknow, a part of Upper Gangetic Plain, lies in the sub-tropical zone. It receives 90–100 cms. annual rainfall, mostly between July to October (rainy season). Winter and summer seasons are almost dry. Such an area with hot dry summer and almost dry winter, lying in the sub-tropical zone, does not precisely fit into any of the four plant climates of Raunkiaer. The three climatic seasons have each a distinct vegetational growth period. A majority of herbaceous plants which grow during rains and winter are not able to survive the hot dry summer. The rainy season annuals find even the winter unbearable ; most of them, therefore, complete their life cycle during the rains but persist in the form of seeds in unfavourable seasons.

In table 2, are given the Biological Spectra of Lucknow, Allahabad, Death Valley California, Libyan desert and Tripoli and also a Normal Spectrum. All the five localities mentioned above lie in the sub-tropical zone and their Biological Spectra are known. The first two are characterized by a hot dry summer and an almost dry winter but the latter three have a dry summer and a humid winter. The Biological Spectrum of Lucknow reveals that the Therophytes are in preponderance (Th = 52·2%) ; they are about four times of that in the Normal Spectrum, where they are only 13%.

The groups next in importance are Nanophanerophytes (11·5%), Hemicryptophytes (10·2%), and Cryptophytes (8·5%). But out of these, the percentage of Cryptophytes only exceeds that of the Normal Spectrum, where they are 4%.

The preponderance of Therophytes in Lucknow Flora makes it comparable to that of Allahabad where the Therophytes are 41·6%. The Biological Spectra of Lucknow and Allahabad—both areas within subtropical zone, with a dry summer and almost a dry winter—are almost identical in that both have a perponderance of Therophytes. This is comparable to the Bilogical Spectra of Death Valley California, Libyan desert, and Tripoli where the Therophytes are 42%, 42% and 51% respectively. Although geographically situated far from one another, yet all the three areas have a humid winter and are situated in a sub-tropical zone.

Our observations clearly indicate that even in a sub-tropical zone with an almost dry winter the Therophytes preponderate ; indicating a clear affinity with sub-tropical regions with a humid winter. Our data, therefore, extend the scope of Raunkiaer's hypothesis.

Our findings are in consonance with Dudgeon's (1920) conclusions that the annuals dominate in this region. Varma (1936) has also concluded that there is a seasonal change of flora from tropical to temperate and to desert conditions ; thus a certain species which exists in one season may not continue to grow in the next.

Summary and Conclusions

1. A biostatistical study of the flora of Lucknow has been made on the basis of Raunkiaer's Life-Form system.

2. The flora of Lucknow is characterized by the preponderance of Therophytes.

3. A comparison between the Biological Spectra of Lucknow, Allahabad (regions in the sub-tropical zone with almost dry winter); Death Valley California, Libyan desert, and Tripoli (regions in the sub-tropical zone with

winter rains) is made and it is shown that the regions in the sub-tropical zone with *dry winter* may also be characterized by a Therophytic climate, as advocated by Raunkiaer for the regions in sub-tropical zone with *humid winter*. Our data, therefore, extend the usefulness of Raunkiaer's system.

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*Not seen in original.

EFFECT OF DIET ON THE PERCENTAGE OF WINGED MALES IN *LACCIFER LACCA* KERR (COCCOIDEA : HEMIPTERA)*

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Introduction

Dimorphic males are of common occurrence in aphids and coccids. But information on the factors affecting the relative proportions of the winged and apterous forms in coccids is obscure. Divergent views have been held by some authors in the case of aphids. Evans (1938) is of the opinion that the proportion of winged forms of *Brevicornye brassicae* varied with the protein content of the host (cabbage) plant. Schaefer (1938) correlates the variations in the percentage of winged forms to the water balance of the immature insect. Partial starvation resulting in a lesser water content increases the percentage of winged forms. Shull (1942) supposes that a lower temperature and intermittant light may be responsible for a higher yield of alate forms. The present study was undertaken to study the effect of partial starvation on the percentage of winged males in the Indian lac insect, *Laccifer lacca* Kerr. (fam. Lacciferidae).

Observations

During the course of observations on the population of males in the *Katki* and *Agahni* crops of *Laccifer lacca* in the year 1961 it was noticed that a few winged forms were also present which were so far thought to be totally absent in these crops (Negi 1929, Misra 1931, Glover 1937). It was noticed that the winged forms were confined to the harder portions of branch of the host tree and in an earlier stage of development than the apterous forms. In the following year (1962) a certain percentage of the brood of the winter crops were subjected to partial starvation in the following ways :

1. Delay in innoculation ;
2. Using uncommon host plants ;
3. Using common host plants made unsuitable by avoiding prior prunning, etc.

The samples under experiment yielded a considerable number of winged forms (3% to 5% of the total population of males, Table I). The experiments were further tried on the summer crops resulting in the increased production of the winged forms over the usual and normal percentage, found thereon (Table II).

When uncommon host plants were used the precentage of winged forms in the summer crops went upto 78% of the total population of males.

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*The paper forms a part of the thesis submitted by the Junior author, G. P. Tulsyan for the Ph.D. degree of Ranchi University, Ranchi.

TABLE I

Number of winged forms per 1000 population of males under normal and treated conditions in the winter crops (Katki and Agahni 1962).

Crops	Under normal conditions	Host tree not prunned, innoculation normal	Host tree prunned, innoculation delayed by 12 days	Host tree not prunned, innoculation delayed by 12 days
Katki	nil	1	6	48
	nil	nil	4	5C
	nil	2	8	51
	nil	nil	5	51
	1	nil	9	52
	nil	nil	6	49
	nil	nil	7	50
	nil	1	4	48
	nil	nil	9	48
	nil	nil	5	49
Mean average	rare	0·4	6·3±2·7	49·6±2·4
Agahni	nil	1	3	29
	nil	nil	5	32
	1	2	2	27
	nil	1	1	29
	nil	nill	nil	32
	nil	nill	7	31
	nil	1	8	30
	1	1	10	29
	nil	2	4	32
	nil	nil	2	27
Mean average	rare	0·8	4·2	29·8±2·8

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Number of winged forms per 1000 population of males under normal and treated conditions in the summer crop (Baishakhi and Jethwi 1963)

Crops	Under normal conditions	Host tree not prunned, innoculation normal	Host tree pruned, innoculation delayed by 12 days	Host tree not prunned, innoculation delayed by 12 days
Baishakhi	440	468	524	570
	456	470	530	564
	442	475	528	555
	464	480	536	568
	466	474	537	562
	467	482	520	558
	458	487	513	556
	470	470	514	560
	440	476	532	564
	446	484	518	565
Mean average	455 ± 15	477 ± 17	525 ± 12	562 ± 8
Jethwi	364	405	416	443
	370	392	422	438
	384	390	415	430
	378	404	402	436
	396	410	399	458
	398	396	421	461
	362	378	427	448
	374	385	408	436
	380	388	409	456
	396	392	422	425
Mean average	388 ± 18	394 ± 16	415 ± 14	443 ± 18

Discussions

The present author's (Tulsyan, 1964) genetical studies on the two forms of the male lac insects have established that they are identical in their chromosome number and morphology. Moreover, their absence in the winter crops and wide variations in the relative proportion in the summer crops cannot be explained genetically. The available information on the factors affecting their relative proportion is confined to the aphids where the most tangible explanation is suggested by Shaefer (1938) who beleives that a lesser water balance of the immature insects caused by partial starvation would result in a higher percentage

of the winged forms. The present studies go in favour of Shaefer's contention. A delayed innoculation; use of unsuitable host plants etc. would inevitably cause partial starvation of the feeding larvae. The two factors, namely the use of unprunned host plants and delayed innoculation when tried separately gave a mean average increase of 2·2% and 7% respectively (over the normal percentage of winged forms in the *Baishakhi* crop). While the two factors taken together gave an increase of nearly 13·7% in the same crop. The corresponding figures in the case of *Jethwi* crop being 1·4%, 3·5%, and 6·3%. The unseemingly high percentage of winged forms recorded on uncommon host plants furnishes a conclusive proof of the effect of starvation on the percentage of winged forms. From a scrutiny of the table on the longevity of the males in Misra's (1931) paper it would appear that the two forms emerge at about the same time. This goes contrary to the present authors' findings. We have noticed that in normal cases the winged forms are delayed by nearly two weeks in their emergence over the apterous ones.

In all the four crops partially starved larvae have yielded a greater percentage of winged males than the normally fed ones.

Summary

The effect of partial starvation on the percentage of winged males is discussed in light of the observations made during the years 1962 and 1963. It has been noticed that there is a considerable increase in the percentage of winged forms following partial starvation of the immature insects. Partial starvation was induced in three ways : (*i*) delayed innoculation ; (*ii*) use of uncommon host plants and (*iii*) use of common host plants made unsuitable by avoiding prunning. The occurrence of winged forms in the winter crops *i.e.* the *Katki* and *Agahni* crops are reported for the first time.

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NEW RECORDS OF SPECIES FOR "FLORA OF ALLAHABAD"

By

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Consistent with the objectives of the Botanical Survey of India for bringing out the "Floras" of the towns/cities where the regional circles are situated and bearing in mind the inadequacy of the information contained in the "Flora of Allahabad" by G. D. Srivastava (1938 ; 1949) a scheme for the preparation of an "Illustrated Manual" on the flora of Allahabad dealing with wild and exotic elements in the flora of this University town was initiated immediately after the inauguration of the Central Circle of Botanical Survey of India in 1962 at Allahabad. In 1964 the scheme was turned into a research project and the author joined as research scholar in July, 1964.

The area for this "Manual" is delimited by natural boundaries in the north and east by the river Ganges and in the south by the river Yamuna ; Bamrauli has been treated as the western-most boundary.

Based on sporadic collections made in 1962 and 1963 by Central Circle, Botanical Survey of India and considering "Flora of Allahabad" (Srivastava l.c.) as the basis for comparison, abstracts of two papers, listing therein about 15 species as new records for Allahabad were published in the *Proc. Ind. Sci. Cong.* (*c.f.* Panigrahi and Arora 1962 ; Arora *et al* 1964).

A thorough study of about 700 field nos. collected so far establishes 17 more species, excluding the family Gramineae, as new record of species for this area considering the works of Srivastava (1938 ; 1949) Panigrahi and Arora (1962) and Arora *et al* (1964) as the basis for comparison. Since the species reported by Panigrahi and Arora (l.c.) and Arora *et al* (l.c.) are mere lists of names, this paper presents description of the habit and notes on habitat, phenology and locality of occurrence of 24 species including those listed by them. The latter are asterisked in the enumeration appended to this paper. Short comments on the distinguishing characters of these species from their allied earlier recorded ones from this area, have also been given against each species and illustrated diagrams depicting the habit and floral parts have been drawn only against species indicated. A full paper dealing with about 350 species collected and identified uptodate within the area of the "Manual" is under preparation.

The following abbreviations are used for the Floras given against them.

FBI—The Flora of British India by J. D. Hooker *et al.*

Duthie—Flora of the Upper Gangetic Plain and of the Adjacent Siwalik and Sub-Himalayan Tracts by J. F. Duthie.

Gamble—Flora of the Presidency of Madras by J. S. Gamble and C. E. C. Fischer.

Haines—Botany of Bihar and Orissa by H. H. Haines.

EXPLANTION TO THE ILLUSTRATIONS

A—depicts the habit of the species ; B—an enlarged view of a flower ; C—l. s. of the flower ; D—an enlarged view of calyx ; E—a sepal ; F—petals and their arrangement in a flower ; G—a corolla ; H—corolla tube opened to show stamen arangement ; I—an enlarged view of stamen ; J—gynoecium on the pedicel ; K—T. S. of ovary ; L— fruit with persistent calyx ; M—l. s. of fruit ; N—a seed ; O—corona ; P—pollinium ; Q—clavate hairs ; R—spathe opened to show flower arrangement ; S—section of leaf showing thickness and shape in t. s.
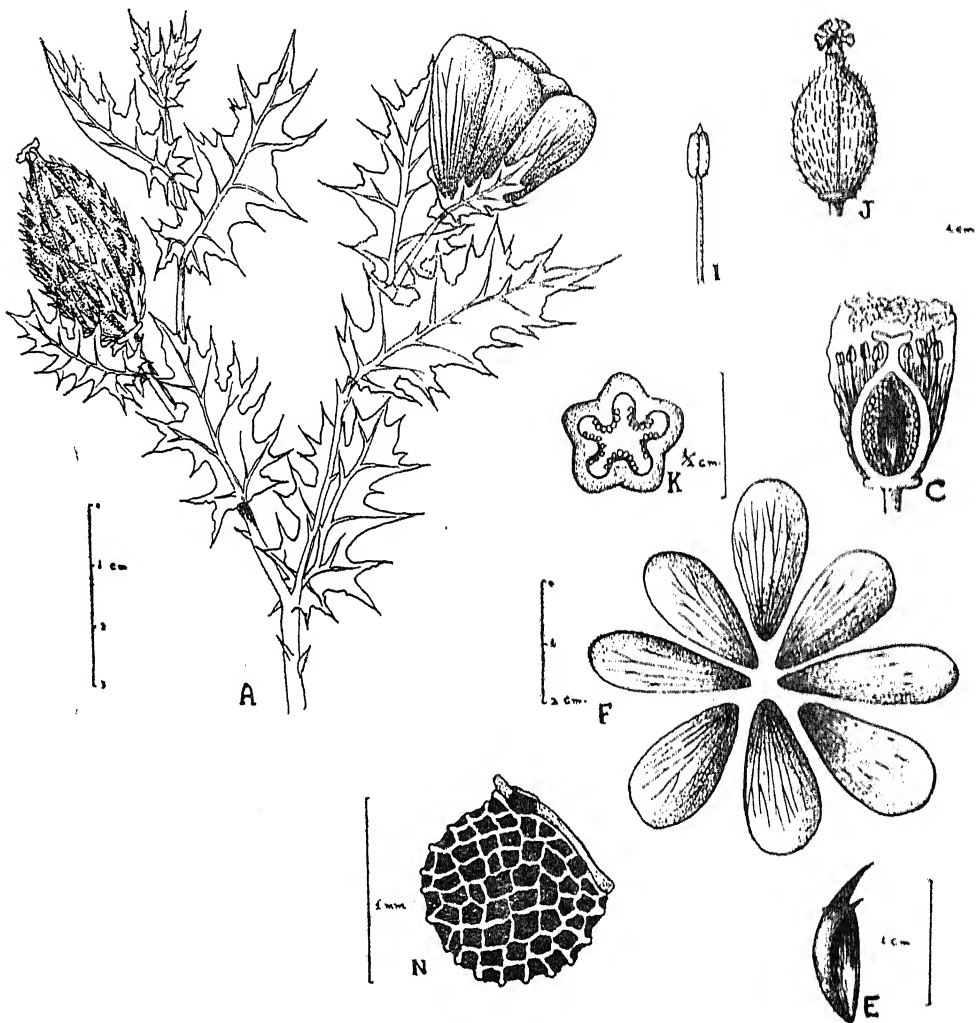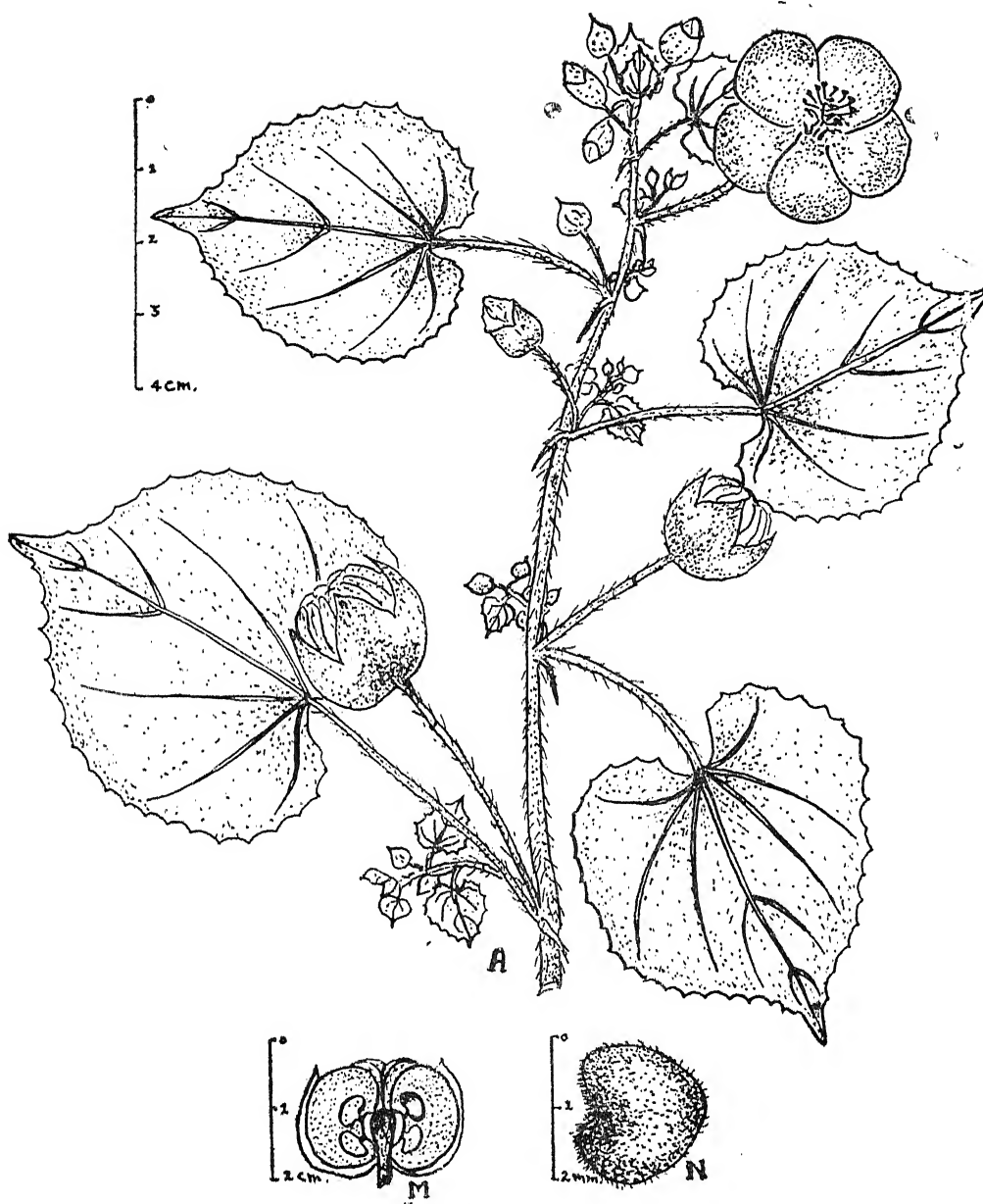

Fig. 1. *Argemone ochroleuca* Sweet.

Fig. 2. *Abutilon hirtum* G. Don.
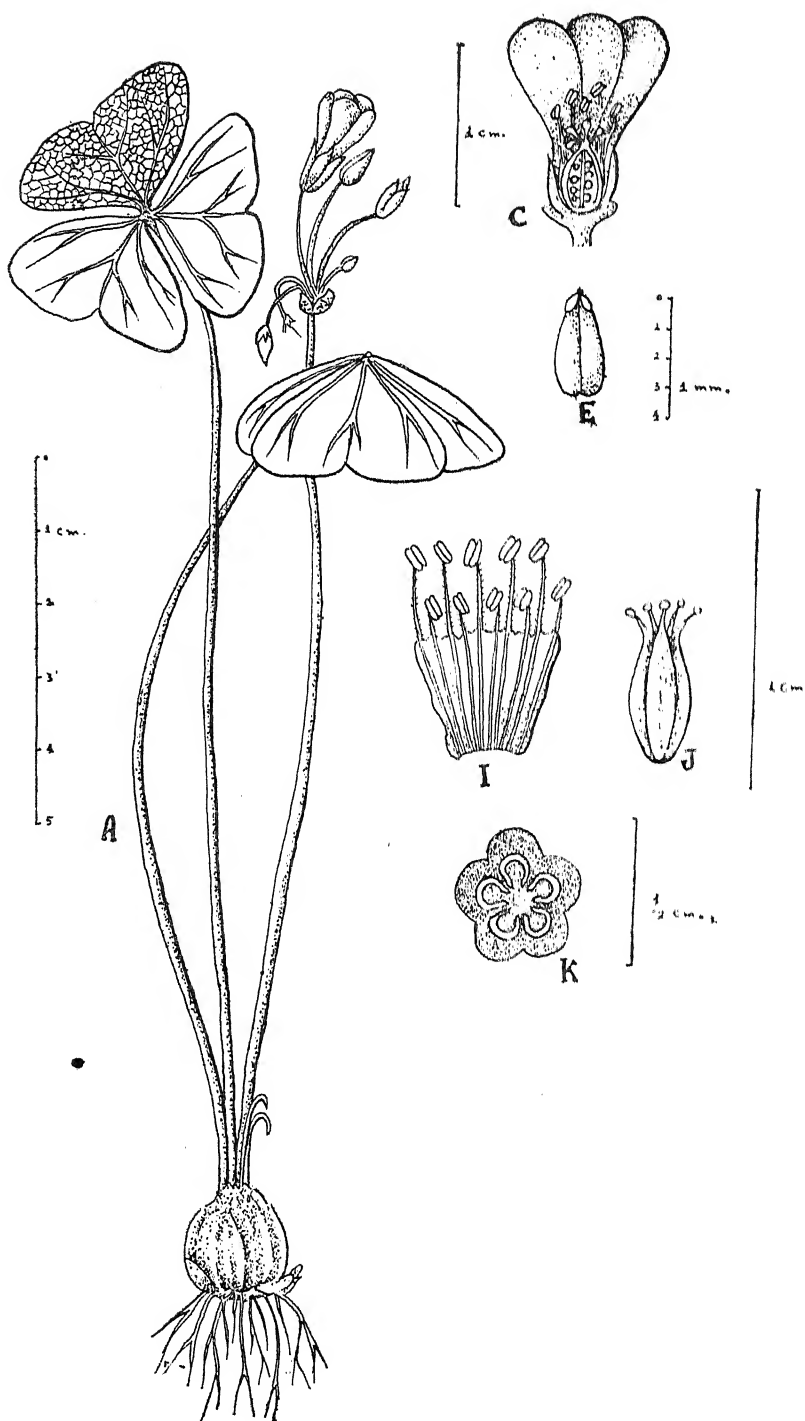
Fig. 3. *Oxalis latifolia* H B. & K.
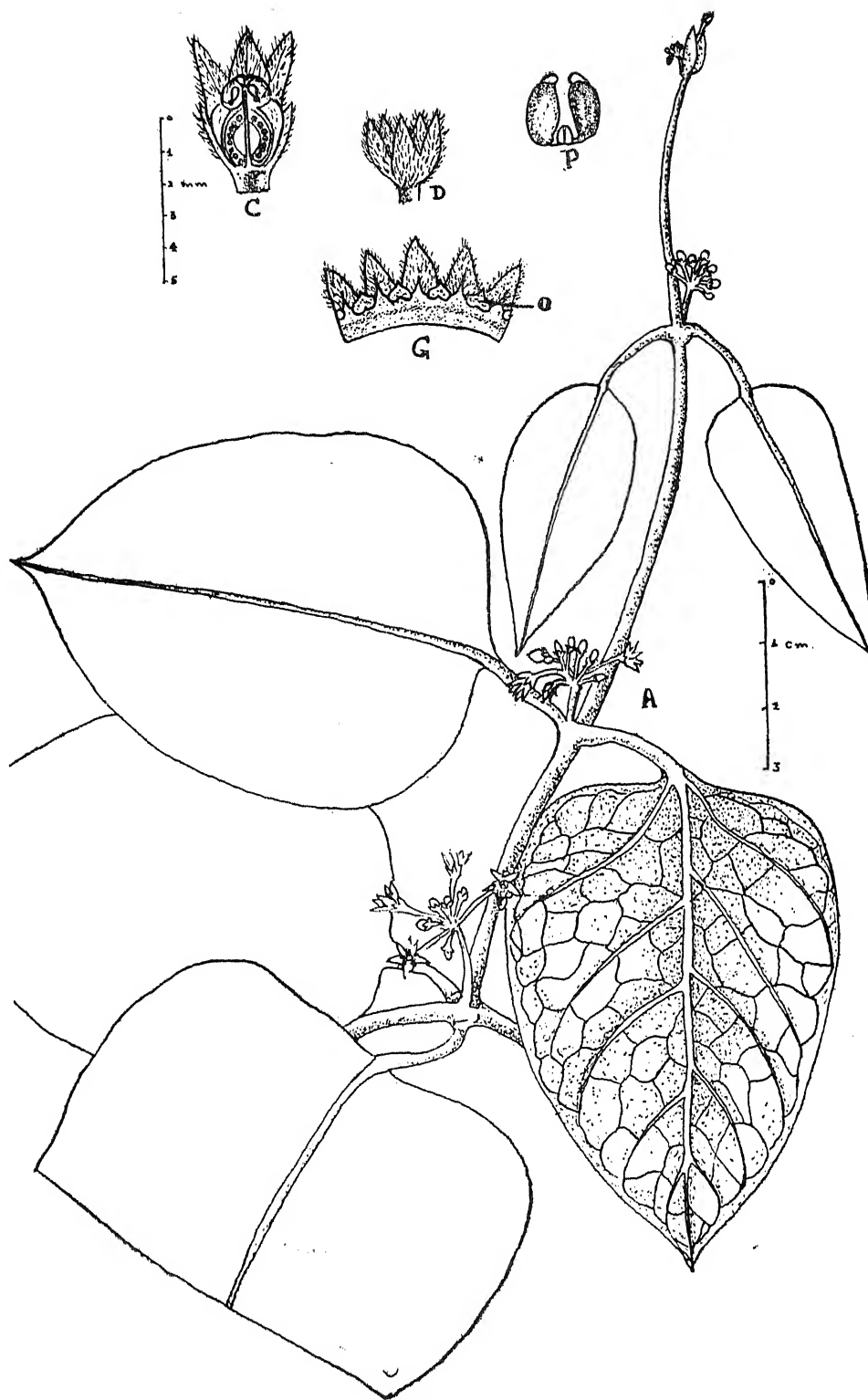
Fig. 4. *Leptadenia reticulata* (Retz.) W. & A.

Fig. 5. *Dregea volubilis* (Linn. f.) Benth ex Hook. f. var. *volubilis*.

N.B. The identity of this species has not been finally established
and seems to be doubtful.

Fig. 6. *Ceropegia bulbosa* Roxb. var. *bulbosa.*

Fig. 7. *Ceropegia bulbosa* Roxb. var. *lushii* Hook. f.

Fig. 8. *Lindernia ciliata* (Colsm) Pennell.

Fig. 9. *Mazus japonicus* (Thunb.) Ktze.

Fig. 10. *Commelina hasskarlii* Clarke.

Papaveraceae
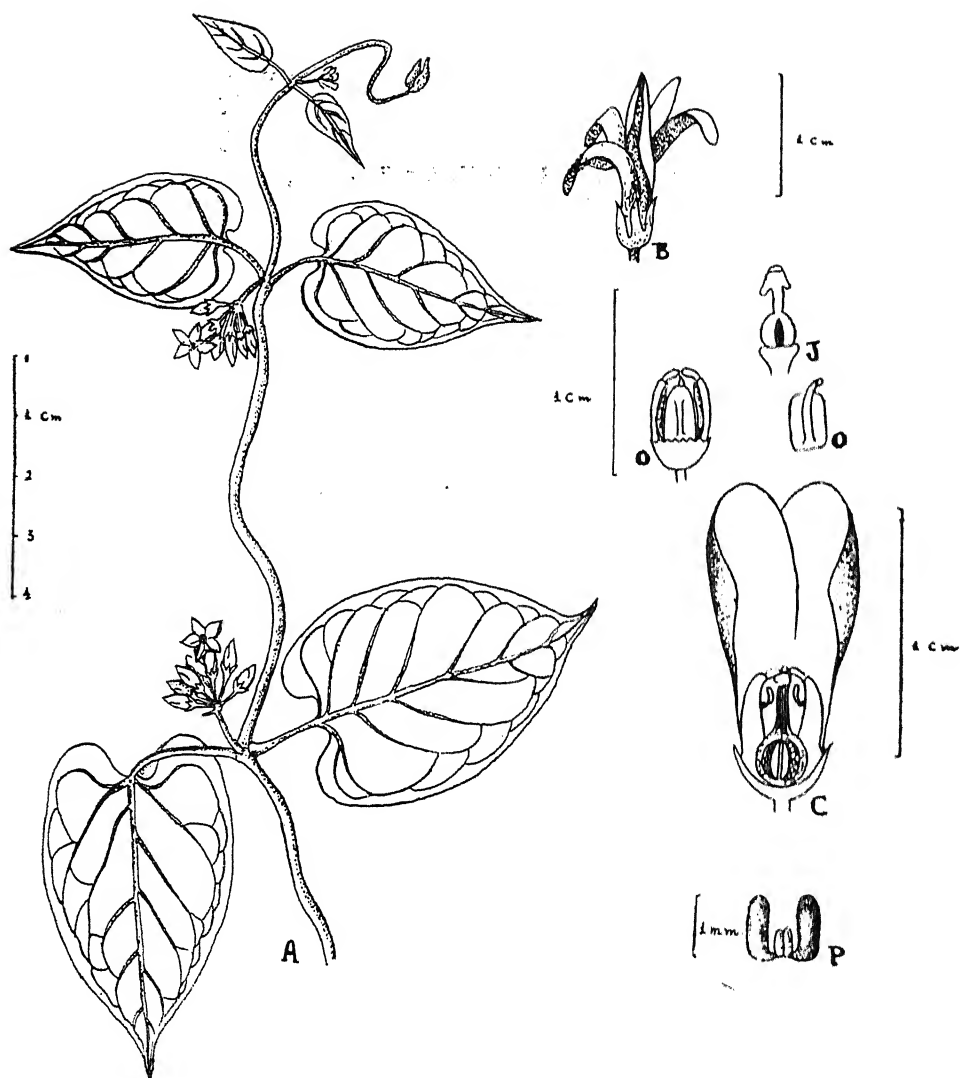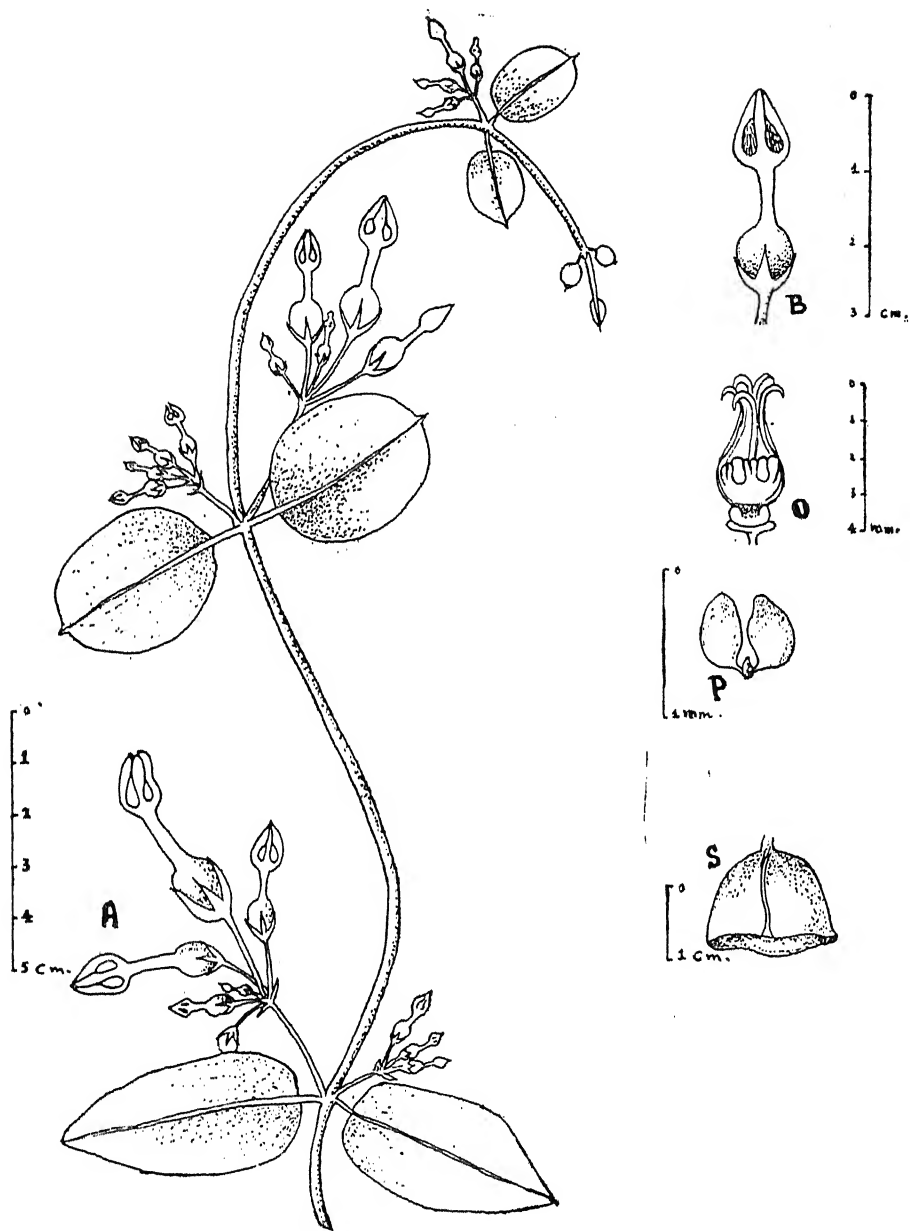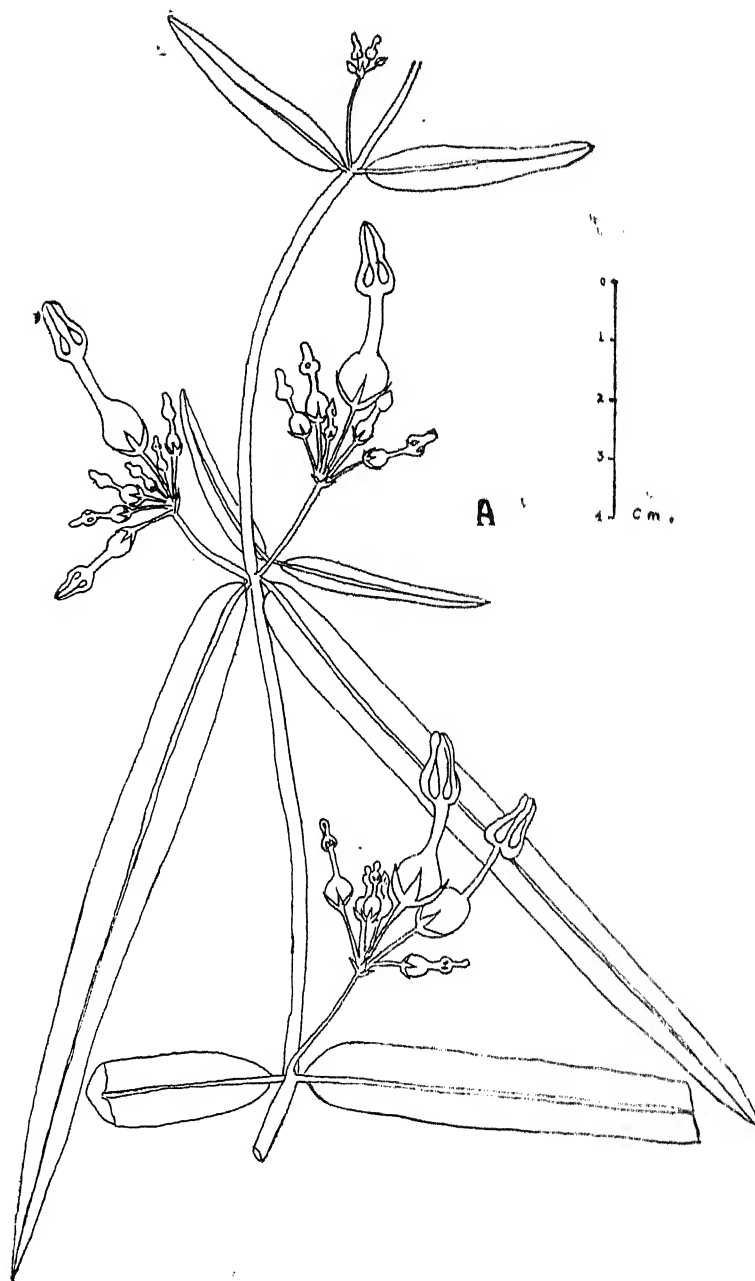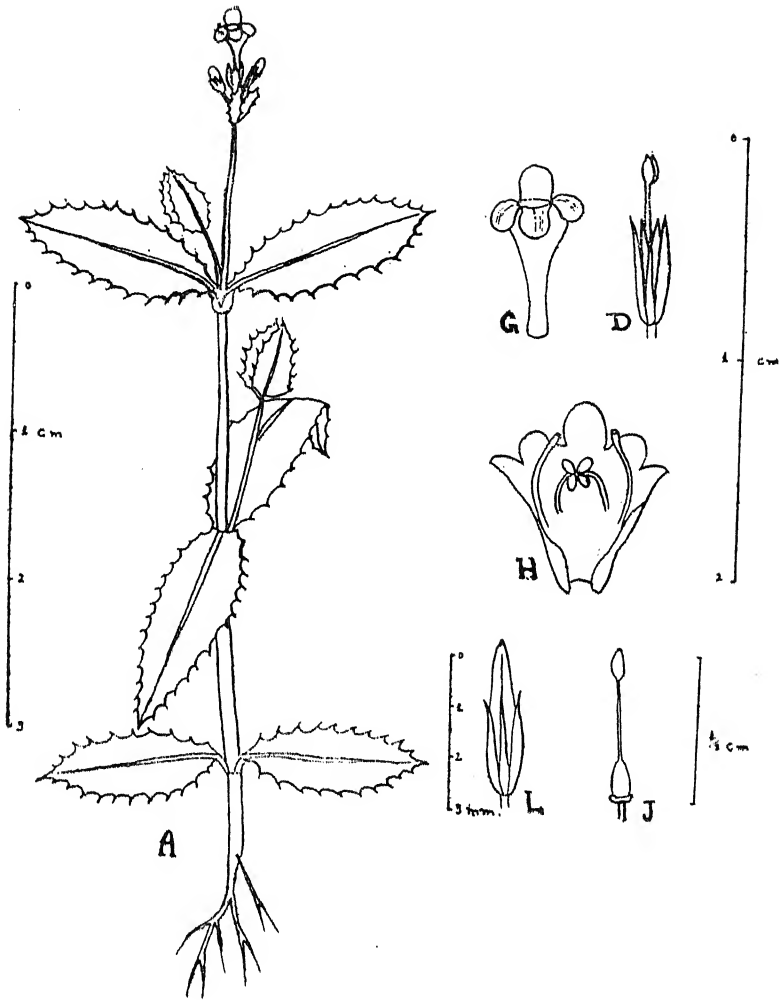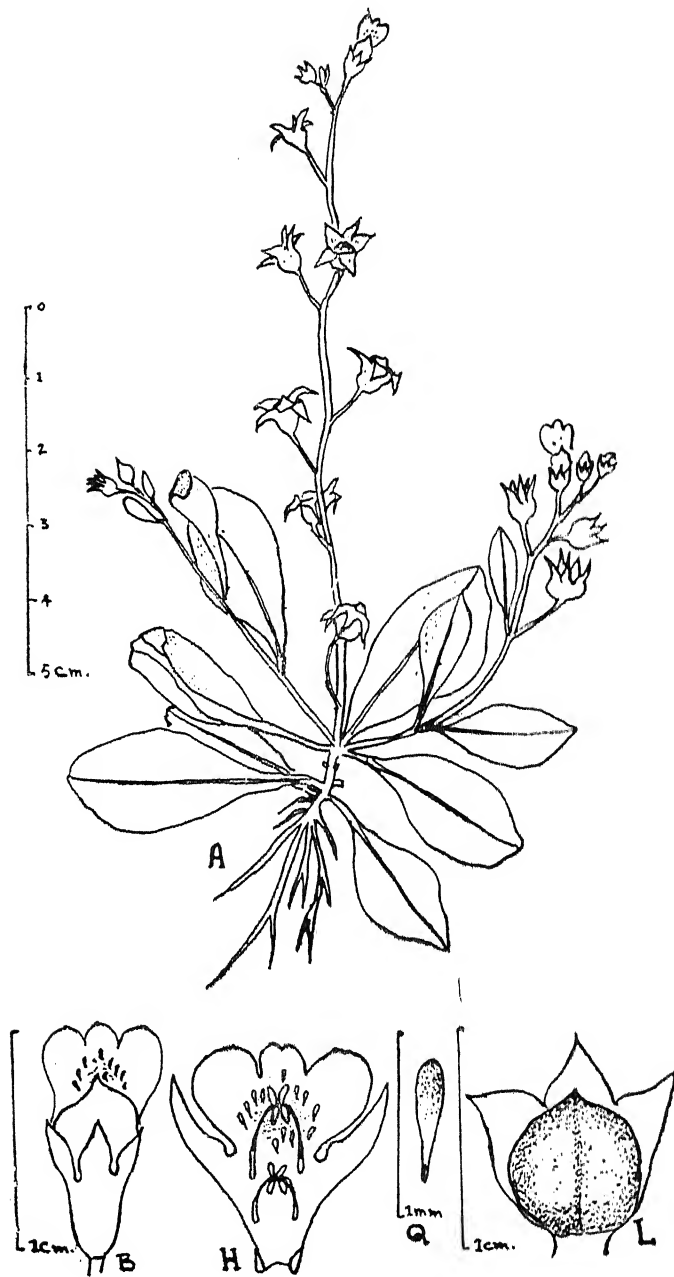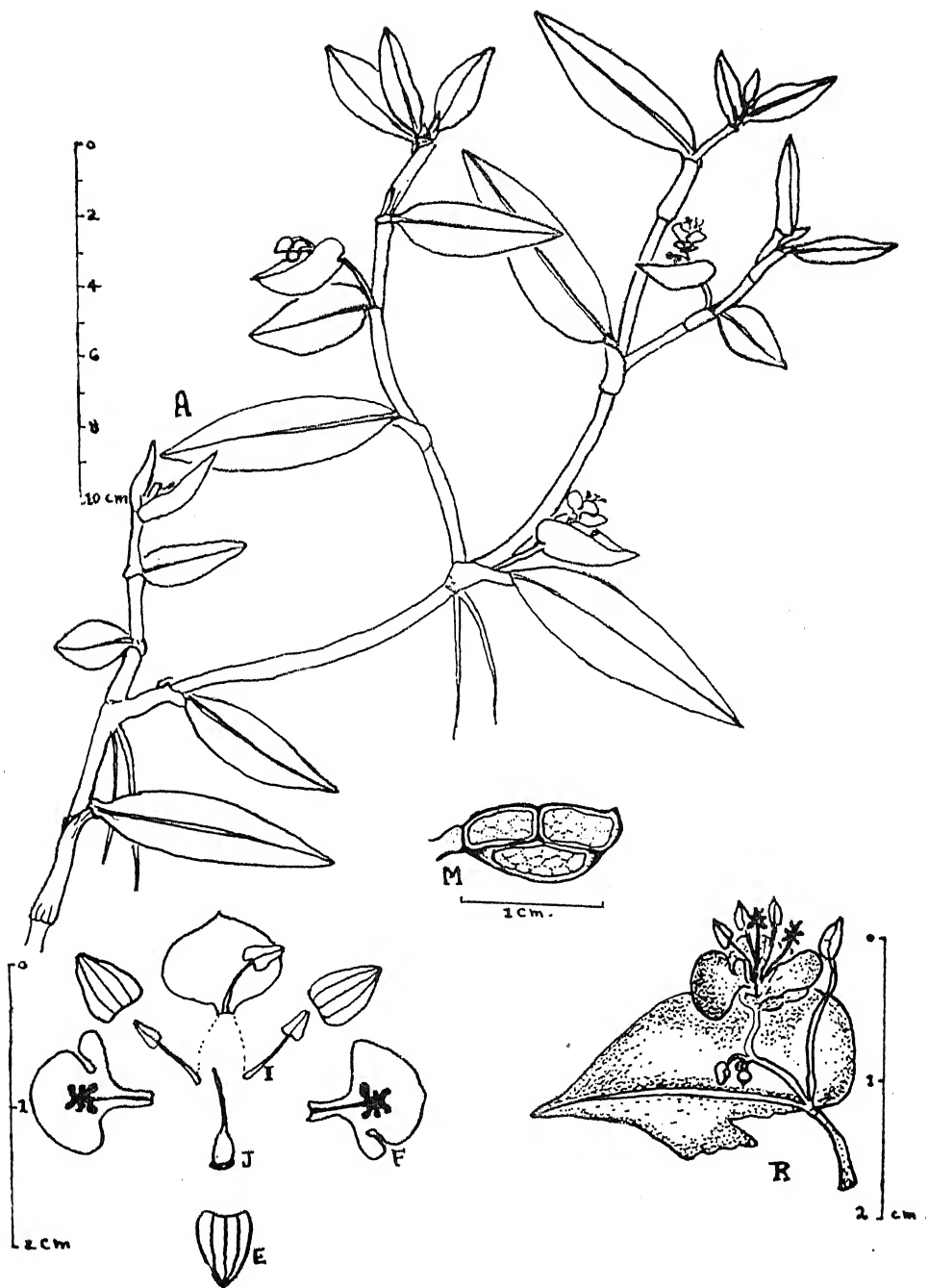
Argemone ochroleuca Sweet. Brit. Fl. Gard. 3 : t. 242 (1828); Venkatesh, in
Proc. Ind. Sci. Cong., (1960) 401.

An erect, annual, armed herb with yellow juice. Leaves spiny toothed,
semiamplexicaul. Flower buds oblong, subsessile, petals light lemon yellow in
colour and crumpled in the bud ; stamens many ; ovary lobed with short spines,
stigmas borne on short style, lobed, stigmatic rays spreading. Capsule armed,
dehiscent at top by short valves exposing black seeds. (Fig. 1.)

Sangam, *T. Rajagopal* 4166/2.

A. ochroleuca Sweet. is a native of Mexico ; it is reported from Delhi by
Venkatesh (1960) and from Patiala by Malhotra (1960). Recently Panigrahi has
observed a population of about 500 plants with white flowers in July at Golganj
(District Raiban) in M. P. (*Panigrahi* and *Singh* 4201). In all these places it grows
associated with *A. mexicana*. Duthie (1903) attributes "yellow or rarely white"
flowers to *A. mexicana* Linn., whereas Srivastava (1938) reports only yellow-flowered
biotypes of *A. mexicana* Linn. from Allahabad and does not describe the stigmatic
surface.

A. ochroleuca with n=28 (*c.f.* Malhotra 1960) is distinguished from the allied
species *A mexicana* Linn. with n=14 by white flowers (Malhotra l.c. and Mahesh-
wari, J. K. 1963) and subsessile lobed stigma. The biotypes in the Allahabad
Flora although possess subsessile lobed stigma, are characterised by light lemon-
yellow flowers (*c.f.* Venkatesh 1962).

On morphological and cytological evidences Malhotra (1960) reports occur-
rence of natural hybrids between *A. ochroleuca* and *A. mexicana*, which generally
grow together showing variations in petal colour *viz.* white, light lemon-yellow and
perfect yellow. Both *A. ochroleuca* Sweet and *A. mexicana* Linn. at Allahabad
exhibit very low percentage of pollen fertility (*viz.* 10 to 15%) and cannot be dis-
tinguished from each other in an herbarium except for their differences in
stigmatic features. My observations also show that *A. ochroleuca* with light lemon
yellow flowers at Allahabad possess n=28, whereas typical *A. mexicana* plants are
characterised by n=14.

Capparidaceae

Capparis spinosa Linn. var. **vulgaris** Hook. f. and Thoms. FBI. 1,173.

A perennial climbing shrub with laterally flattened stipular hooked thorns
in pairs. Leaves ovate-oblong, glabrous above and woolly beneath. Older branches
leafy. Fruit oblong and borne on a long gynophore which is much longer than
the woody pedicel, and somewhat lobed with reticulate pattern.

Fruiting during summer.

Behind Polytechnical College, *V. N. Singh* 568.

G. D. Srivastava (1938) describes three species under the genus *Capparis viz.*
C. decidua (Forsk.) Edgew. (=*C. aphylla* Roth.), *C. sepiaria* Linn, *C. zeylanica* Linn.
Although Duthie (1903) has considered *C. spinosa* Linn. as non-existing within the
area of his flora but confined to valleys of Himalayas, Punjab and Sind, Haines
(1921) has reported *C. spinosa* Linn. var. *leucophylla* DC. from stony valleys in
Bettiah of Bihar. The plant identified to *C. spinosa* Linn. var. *vulgaris* Hook. f.
and Thoms. differs from the other species of *Capparis* at Allahabad as follows :

1. Mature branches leafless, thorns straight, flowers red, fruit globose
   red..... ....*C. decidua.*
1. Mature branches leafy :

2. Flowers solitary, thorns hooked, fruit oblong unevenly lobed, larger (1·5 to 2·5 cm.) than those of the others... ....*C. spinosa*

2. Flowers in umbels or supra-axillary rows :

    3. Flowers in umbels, white, small, spines recurved ....*C. sepiaria*

    3. Flowers in supra-axillary rows and young parts tomentose..*C. zeylanica*

C. spinosa var. *vulgaris* at Allahabad is sometimes, on the basis of its' description by Hooker (FBI. 1,174), confused with *C. grandiflora* Wall. But Wight (Wight Icon. Plate 104) attributes leaves with cordate base and pedicel equalling the length of the leaves to *C. pyrifolia* W. & A., which is synonymous to *C. grandiflora* Wall., whereas *C. spinosa* Linn. var. *vulgaris* Hook. f. and Thoms. has leaves with acute base and pedicel shorter than the leaves. Besides, *C. grandiflora* Wall. is endemic to Nilgiri Hills. Therefore, the Allahabad plants referred above are identified to *C. spinosa* Linn. var. *vulgaris* Hook. f. and Thoms.

Malvaceae

Abutilon hirtum G. Don in Gen. Syst. 1,503 (1831) ; *A. graveolens* W. & A. var. *hirtum* Masters in FBI 1,327. Gamble 1,65 ; Haines 1,64.

An erect herb with a woody stem and spreading hairs and mixed with a tomentum and glandular hairs. Leaves cordate, abruptly acuminate with minute projecting teeth from the margins. Flowers yellow 1–3·5 cm. across, borne on two axillary peduncles, one of which terminate in a single flower and other into a flowering branch bearing 3–5 flowers. Carpels with wavy valves and short stellate white hairs and almost as long as the enlarged calyx. Seeds greyish black with minute hairs. (Fig. 2.)

Grows in waste, places. Flowers and fruits during September to October.

Salori, *T. Rajagopal* 6134 ; *V. N. Singh* 955.

A. hirtum differs from the other species *A. indicum* (Linn.) Sweet and *A. asiaticum* (Linn.) Sweet occurring at Allahabad (*c.f.* Srivastava 1938) as given below :

A. indicum (Linn.) Sweet	*A. asiaticum* (Linn) Sweet	*A. hirtum* G. Don
1. Stem closely tomentose, woolly to touch.	1. Stem with spreading hairs.	1. Stem with spreading hairs and mixed with tomentum and glandular hairs.
2. Ripe carpels with scattered tufts of stiff hairs, eventually deciduous, and with sharp spreading beaks or awns.	2. Ripe carpels with dense spreading persistent shaggy hairs and with short erect awns or beaks.	2. Ripe carpels shortly pubescent but without awns or beaks.
3. Seeds minutely furrowed, glabrous.	3. Seeds glabrous.	3. Seeds with minute hairs.
4. Pollen with spines having straight base.	4. Pollen with spines having straight base.	4. Pollen with spines having bulbous base.

Although many of the Indian Floras treat *A. indicum* (Linn.) Sweet and *A. asiaticum* (Linn.) Sweet as two distinct species, Santapau and Wagh (1963) cite the latter as synonymous to the former species. Nair (1962), who has made a study of the pollen grains of the two species, reports occurrence of "spines with straight base" common to the pollen grains of the two species. Our own observations on

the gross morphology of the two species collected and represented in the Central Regional Herbarium, Allahabad, lead us to support Santapau and Wagh (l.c.), at least, at present. It is, therefore, proposed to recognize the occurrence of only two species of *Abutilon* at Allahabad viz. *A. indicum* (Linn.) Sweet [= *A. asiaticum* (Linn.) Sweet] and *A. hirtum* G. Don.

Geraniaceae

Oxalis latifolia HB. and K. in Nov. Gen. et Sp. 5,237 (1821) ; Calder, Rec. Bot. Surv. Ind. 6,335 (1919) ; Raizada. M. B., J. Ind. Bot. Soc. 10, 155–58 (1931).

A herb with simple bulbs producing radical leaves ; leaves long slender petioled, with three obcordate sessile leaflets. Flowers in umbels, borne on a long slender peduncle arising from the underground bulb. Sepals 5-nerved, persistent, with two glands (yellowish pink) at the apex. Petals free but united at the base only, pink in colour, turning violet-blue when dried or pressed. Stamens 10, (sometimes 12) alternately longer and shorter, filaments united below to form a membranous cup. Styles 5 (sometimes 6–8) distinct with capitate stigma, ovary elongate and lobed. Ripe capsule not seen. (Fig. 3).

Khusrobagh, *T. Rajagopal* 2291 ; Chatham Lines, *C. M. Arora* 4404.

A native of Mexico naturalized at Dehra Dun (*c f. Raizada* 1931) ; grows at Chatham Lines and at Khusrobagh area on moist places during rainy season and also in winter, probably as a garden escape ; not reported in Indian Floras. It is easily distinguished from the other allied exotic species viz. *O. martiana Zucc* (= *O. corymbosa* DC. *c.f.* Srivastava 1938) in the following characters :

O. latifolia HB. & K.	*O. martiana zucc.*
1. Bulbs simple.	1. Bulbs compound.
2. Obcordate leaflets triangular with a notch in the Centre.	2. Obcordate leaflets with rounded edges with a notch in the centre.
3. Inflorescence in simple umbels.	3. Inflorescence in compound umbels.
4. Sepals with 2 pinkish yellow glands at tip.	4. Sepals glandular.

Leguminosae

Alysicarpus vaginalis DC. in Prod. 2,353 (1835) : FBI. 2,158 ; Duthie 1,255.

An erect undershrub 30 cm. to 1 m. high. Leaves 1-foliolate, glabrous, cordate, variable in shape and size, lower lanceolate, upper oblong to ovate, emarginate. Stipules ovate acute, half the length of the petiole and parrallel veined. Racemes lax ; calyx as long as the first joint of the pod ; corolla small, pinkish with yellow tinge. Pods terete, reticulate-veined, 6–8 jointed.

Flowers and fruits during September to November.

Chatham Lines, *C..M. Arora* 4729.

A. vaginalis is distinguished from the other allied species occurring at Allahabad (*c.f.* Srivastava, 1938, 1949) as follows :

1. Calyx as long as the first joint of the pod or shorter.
   2. Pods not veined and moniliform........................ ...*A. monilifer*
   2. Pods veined, not moniliform ....*A. vaginalis*
1. Calyx longer than the first joint of the pod.

3. Pods finely reticulate-veined or ribbed.

    4. Pods finely reticulate-veined.............................. *A. longifolius*

    4. Pods ribbed and 2-edged................................... *A. rugosus*

3. Pods neither veined nor ribbed............................... *A. bupleurifolius*

Teramnus labialis (Linn. f.) Spreng in Syst. 3,235 (1826) ; FBI. 2,184 ; Duthie 1,214.

A twining herb ; stem shortly pubescent. Leaves pinnately 3-foliolate ; leaflets, ovate acute, glabrous. Flowers reddish-white in very slender and glabrous racemes ; calyx teeth subequal and as long as the tube ; stamens monadelphous with alternate stamens sterile. Pod glabrescent, about 5 cm. long, thin, hooked, dehiscent along both the sutures ; valves twist in spirals.

Flowering and fruiting from September to November. It grows on hedges and bushes.

Chatham Lines, *C. M. Arora* 4782 ; Alfred Park, *V. N. Singh* 911.

Cassia surattensis Burm. f. Fl. Ind. 97 (1768) ; *C. glauca* Lamk. FBI. 2,265 ; Duthie 1,268.

A shrub or small tree, about 3–7 m. high. Leaves distinctly petioled, 15–22·5 cm. long ; leaflets ovate, acute ; much variable in size. Racemes corymbose ; flowers large, yellow ; stamens 10, all equal. Pods thin flat, strap-shaped, glabrous, prominently stalked, 20–30 seeded.

Flowering and fruiting from August to November.

Chatham Lines, *C. M. Arora* 4734 ; *R. Prasad* 394.

Cassia surattensis Burm. f., with its erect racemes and strap-shaped pods is easily distinguished from *Cassia fistula* Linn., which is characterised by drooping racemes and terete pods.

Ficoideae

Glinus oppositifolia (Linn.) A. DC. Bull. Herb. Boiss. 2, 1 (1901) 552.

Mollugo oppositifolia Linn., Sp. Pl. 89. FBI. 2,662 ; Duthie 1,355.

A slender prostrate herb, nearly glabrous with long internodes. Leaves crispate, spathulate. Flowers in axillary fascicles ; pedicels long, filiform ; sepals glabrous. Seeds—appendaged and with a slender white thread curved round them.

Grows on the banks of Ganges and Yamuna and on sandy dry areas. Flowering and fruiting during June to December.

Naini, *V. N. Singh* 546.

Glinus oppositifolia by its glabrous or glabrescent leaves, and long filiform pedicels, is distinguished from its allied species *G. lotoides* Linn. (*Mollugo lotoides* W. & A. and *M. hirta* Thunb.), the latter being a stellately hairy plant with short pedicels.

Compositae

Grangea maderaspatana (Linn.) Poir. in Encycl. Suppl. 1. 2,825 (1812) ; FBI. 3,247, Duthie 1,407.

A pubescent prostrate annual herb. Leaves sinuately pinnatifid with lobes smaller towards base. Flowers yellow in solitary heads. Involucral bracts densely pubescent ; pappus represented by a short tube.

[39]

A garden weed, also observed on moist sandy loam in waste places. Flowers during greater part of the year.

Salori, *V. N. Singh* 517

Sonchus oleraceus (Linn.) in Sp. Pl. 794 (1753) ; FBI. 3,414 ; Duthie 1,448.

An annual, sparsely glandular herb with nodes covered by semi-amplexicaul leaf bases ; leaves lanceolate, entire or lobed, upper-most ones linear ; auricles of the cauline leaves spreading and acute. Involucral bracts glabrous or sparsely gland pubescent. Achenes compressed, oblong, acute, three-ribbed and muricate in between ; pappus white.

Flowering and fruiting during December to April.

Mintopark, *T. Rajagopal* 2290 ; Chatham Lines, *Hanfi* 723.

Sonchus oleraceus is distinguished from another species *S. arvensis* Linn. recorded for Allahabad (*c.f.* Srivastava 1938) in the following characters :

Sonchus oleraceus Linn.	*Sonchus arvensis* Linn.
1. Auricles of cauline leaves spreading, acute.	1. Auricles of cauline leaves, appressed, obtuse.
2. Involucral bracts glabrous or sparsely gland pubescent.	2. Involucral bracts beset with glandular hairs.
3. Achenes flattened, three ribbed and muricate in between.	3. Achenes slightly compressed, with more than three ribs on each face.

Asclepiadaceae

Leptadenia reticulata (Retz.) W. & A. in Wight Contrib. 47 (1834) ; FBI. 4,63 : Duthie 1,511.

A twining shrub, branched, with watery latex. Leaves petiolate, tomentose when young, ovate or ovate-lanceolate, acute at the apex, round at base. Flowers small greenish, in lateral many-flowered umbellate cymes ; all floral parts pubescent, corona lobes staminal and corollary ; anthers inflexed over the stigma ; pollen mass attached to the pollen-carriers by distinct caudicles, erect, waxy, solitary in each anther-cell, pelucid at the tips, style-apex pentagonal. (Fig. 4.)

It grows on hedges and bushes. Flowering during July to October.

Police Lines, *T. Rajagopal* 3131.

Duthie in his Flora records this species from sub-Himalayan tracts eastwards to Gorakhpur and Bundelkhand, and states that it flowers during May and July.

Dregea volubilis (Linn. f.) Benth. ex Hook. f. in FBI. 4,46 ;

Marsdenia volubilis T. Cooke ; Duthie 1,505.

A climbing branched shrub. Leaves broadly ovate cordate at the base. Flowers in umbellate cymes ; green· or yellowish-green, corolla rotate ; corona lobes fleshy, stellate, adnate below to the staminal column, free above, ending in a cuspidate point ; pollen mass in 5 pairs, waxy, erect ; stigma with flat surface. (Fig. 5.)

Flowers during July to September. It grows on hedges and trees.

Police Lines, *T. Rajagopal* 3130 ; Mac Pharson Lake, *T. Rajagopal* 3130/F : Chatham Lines, *R. Prasad* 3263.

In FBI three varieties were described including the *Dregea volubilis* proper. Santapau and Irani (1960) treated the variety *angustifolia* Hook. f., as a distinct

species. The remaining two varieties viz. *D. volubilis* (Linn.) Benth. ex Hook. f. var. *volubilis* and *D. volubilis* (Linn. f.) Benth. ex Hook. f. var. *mollis* Hook. f. occur at Allahabad. They are distinguished from each other as follows :

1. Plants glabrous.
   var. *volubilis*.

2. Plants pubescent ; older parts glabrescent.
   var. *mollis*.

Ceropegia bulbosa Roxb. Pl. Cor. 1, 11, t. 7 (1795) ; Wight. Icon. t. 845 ; FBI. 4,67 ; Duthie 1,514.

A twining perennial plant, with slender stems arising from tubers ; stems glabrous or glabrescent. Leaves extremely variable in shape and size, linear lanceolate, ovate or orbicular ; acute or acuminate ; cordate or acute at base ; pedicelled or subsessile and fleshy with watery juice. Flowers in peduncled umbellate cymes, pedicels generally shorter than the peduncels ; calyx lobes long, lanceolate, acute ; corolla greenish about 2 to 2·5 cm. long, tube inflated at the base, lobes linear with triangular base, adnate even when dry ; violet purple and villous within ; corona-lobes double, outer 5, minute, inner 5, long filiform. Folicles terete 10 to 12 cm. long, 1 to 1·5 cm. broad and glabrous.

Grows in waste places on *Capparis* bushes. Flowering from July to September, fruiting from August to October.

Behind Polytechnic College, *T. Rajagopal* 3200 and 3200/2.

The species is represented by the two following varieties (*c.f.* Hook. f. describes 3 varieties in FBI. 4,68) at Allahabad.

1. Leaves fleshy 2·5 to 5 cm. long, orbicular, oblong or obovate and ovate in transverse section.. var. *bulbosa*. (Fig. 6).

2. Leaves fleshy narrowly linear upto 20 cm. long and triangular in transverse section........ . ...var. *lushii*. (Fig 7).

The third variety recognized by Hook. f. (l.c.) viz. var. *esculenta* has leaves 10 to 12·5 cm. long and 2·5 cm. broad, shortly petioled and linear lanceolate. Santapau and Irani (1960) cite the varieties *lushii* and *esculenta* as synonymous to *C. bulbosa* proper and state . . . "lamina 2–4 × 1·5–2·3 cm. . . .". But a few biotypes at Allahabad, characterised by fleshy linear leaves upto 20 cm. long and triangular in transvers section and far exceeding the range of variations in leaf length given by Santapau and Irani (l.c.), can easily be identified as *C. bulbosa* Roxb. var. *lushii* Hook. f., which, according to Hook. f. (l.c.), has leaves upto 8 inches in length.

Boraginaceae

Coldenia procumbens Linn. in Sp. Pl. 125 (1753) ; FBI. 4,144 ; Duthie 1,532.

A procumbent herb with young parts silky white. Leaves obovate or oblong rounded at tip, coarsely serrate or subpinnatifid ; nerves impressed deeply. Flowers axillary, white ; calyx 4 or 5-partite ; corolla a short tube, 4-5 lobed ; stamens 4-5 epipetalous ; pyrenes rounded on the back.

Grows on the banks of Ganges and Yamuna and on moist places. Flowering and fruiting June to August.

Sangam, *T. Rajagopal* 4174.

Scrophulariaceae

*Lindernia ciliata (Colsm.) Pennell in J. Arn. Arb. 24,253 (1943) ;

Bonnaya brachiata Link. and Otto. FBI. 4,284 ; Duthie 2,26.

Annual, erect herb upto 15 cm. high. Leaves opposite, sessile, serrate with almost dentate teeth and penninerved. Flowers white with pink dots on the lower side of the lobes ; calyx cleft to the base ; stamens four, two perfect and two staminodes. Capsule nearly twice as long as the calyx. (Fig. 8).

Flowers and fruits from August to December.

Alfred Park, *T. Rajagopal* 3182 ; Chatham Lines, *C. M. Arora* 4706.

It grows in moist places along with blue flowered *Lindernia crustacea* (Linn.) Muell. [*Vandellia crustacea* Benth. (*c.f.* Srivastava 1938)] during rainy season. *L. ciliata* differs from *L. crustacea* as follows :

L. ciliata (Colsm.) Pennell.	*L. crustacea* (Linn.) Muell.
1. Leaves serrate, almost with dentate teeth.	1. Leaves entire or crenate.
2. White flowers with pink dots.	2. Flowers blue or bluish white.
3. Calyx divided upto the base.	3. Calyx divided upto middle.
4. Perfect stamens two.	4. Perfect stamens four.
5. Capsule twice as long as the calyx or longer.	5. Capsule more or less equal to the calyx.

Mazus japonicus (Thunb.) Ktze. Rev. Gen. Pl. 462 (1891) ; *Mazus rugosus* Lour. FBI. 4,259 ; Duthie 2,19.

A glabrous or glabrescent annual erect herb ; stems sometimes tufted and semi-erect. Leaves mostly radical ovate-spathulate, 2–6·5 cm. long, narrowing into a short petiole, crenate or sinuate. Flowers in scapiform racemes 2·5–20 cm. long ; calyx campanulate, enlarging in fruit ; corolla pale-blue or white, bilabiate, upper lip short ; lower lip larger, spreading, 3-lobed with brownish-yellow spots and clavate hairs ; stamens four, didynamous, anthers conniving in pairs and cells contiguous ; style with bi-fid stigma. Capsule-subglobose, laterally flat, included in the persistent enlarged calyx ; seeds pale-yellow, minute and numerous. (Fig. 9).

It grows on moist alluvial loam near drains, river bank and as a weed in lawns. Flowers after rainy season and continues till the end of winter. Chatterjee and Bharadwaja (1955) state "flowers throughout the year".

Allenganj, *T. Rajagopal* 6186 ; University Road, *O. P. Misra* 5366 ; Chatham Lines, *Hanfi* 5314.

Labiatae

*Orthosiphon pallidus Royle ex Benth. in Hook. Bot. Misc. 3,370 (1833) ; FBI. 4,613 ; Duthie 2,100.

A perennial herb with quadrangular stem arising from a woody root stock. Leaves ovate, obtuse or acute, cuneate, crenate or serrate above and entire at the base ; glabrescent but petiole with glandular hairs. Leaves not aromatic. Racemes in short whorls distant, 6–flowered, bracts small pubescent. Corolla white with tube almost equalling the calyx, lower lip concave. Stigma entire.

On open grounds and moist places. Flowering and fruiting June to September.

Chatham Lines, *C. M. Arora* 3815 ; Manauri, *V. N. Singh* 551.

Euphorbiaceae

Euphorbia geniculata Onteg. Nov. Rar. Pl. Matr. 18 (1797) ; Duthie 2,190 ; Haines 1,149.

An erect annual herb about 0·5–0·75 m. high with leaves 3 to 8 cm. long ; ovate-lanceolate, acute. Latex milky. The floral leaves are white near the base and green towards the apex. Flowers light greenish or greenish-pink, clustered, terminal ; capsule smooth, seeds dark grey, truncate at the lower end.

Grows in fields and gardens as a weed and also in waste places. Flowers and fruits during September to December.

Chatham Lines, *O. P. Misra* 5356 ; *C. M. Arora* 3809 ; *V. N. Singh* 559 ; *R. Prasad* 380.

A native of Tropical America. Introduced during last quarters of ninteenth century and now naturalized in many parts of our country.

Jatropha curcas Linn. in Sp. Pl. 1006 (1753) FBI. 5,583 ; Duthie 2,215.

Shrub with whitish wood and greenish white bark. Leaves orbicular cordate, entire or 3–5 lobed. Flowers monoecious ; petals connate upto middle greenish white ; stamens numerous. Fruit a capsule of 2–valved cocci.

Moratganj, *Hanfi* 1843.

Introduced from Tropical America and is generally grown as a hedge plant. The seeds yield an oil which "is used for burning and also medicinally" (*c.f.* Duthie, l.c.)

Jatropha curcas is distinguished from its allied species *J. heterophylla* Steud. (*J. gossypifolia* Linn. *c.f.* Srivastava 1938) by the following salient features.

Jatropha curcas Linn.	*J. heterophylla* Steud.
1. Leaves entire, or 3–5 lobed without stipitate glands on the margins.	1. Leaves entire or 3–lobed with glands on the margin.
2. Petals greenish yellow and more or less cohering.	2. Petals red and free.

Commelinaceae

Commelina hasskarlii Clarke, Comm. and Cyrt. Beng. 13, t. 5 (1874) and in DC. Mong. 3.157 ; FBI. 6,370 ; Duthie 2,339.

A semi-erect annual herb with much branched stem, rooting at nodes. Leaves 2·5 to 8 cm. long, lanceolate ; sheaths broad-based and ciliate. Spathes axillary, ovate-lanceolate, cordate at the base. Flowers blue in unequal cymes, the uppermost branched, 2–4 flowered, the lower 1–2 flowered ; capsule 0·5–0·75 cm. long, membranous, 3–seeded, two in the anterior cell and one in the posterior cell, cylindric, truncate at one end. (Fig. 10).

It grows generally in moist shady places. Flowering and fruiting from November to February.

Chatham Lines, *T. Rajagopal* 2292 ; Malaka, *V. N. Singh* 937.

Duthie in his Flora records it from N. Oudh and states "apparently not common".

*Zygomenes axillaris (Linn.) Salisb. in Trans. Hort. Soc., 1,271 (1812) ;

Cyanotis axillaris (Linn.) Schult. f. FBI. 6,388 ; Duthie 2,344.

An annual herb with semi-erect branches upto 12·45 cm. long. Leaves sessile linear or narrowly lanceolate, with inflated ciliated sheath. Flowers bluish violet, clustered in the axils of inflated sheathes; filaments fusiform below the tip and bearded. Capsule ellipsoid, shortly beaked, without any sinuses in between; seeds rugose and shining brown.

It grows during rainy season in moist places in the edges of lake, drains and in shady situations. Flowers and fruits during August to October.

Mac Pharson Lake, *T. Rajagopal* 3194 ; C. C. Garden, *Arora* 3812 and 3895.

Maheshwari, J. K. (1963) treats this species under the genus *Cyanotis* Don. considering the genus as conserved in the *International Code of Botanical Nomenclature* (1961) ; but the code fails to state against which genera it is conserved. Recently "*Cyanotis axillaris*" and its allied species *C. cucullata* (Roth.) Kunth. have been treated under the genus *Zygomenes* Salisb. and this treatment may find support from the cytotaxonomical studies in the genus, (*c.f.* Sharma and Sharma 1958 ; Kammathy and Rolla 1962).

Cyperaceae

Three annual species for the genus *Cyperus* were found to be new records and they are distinguished from each other as given below :

    1.   Spikelets in elongate subracemose spikes........ . ...*C. iria*

    1.   Spikelets shortly spicate.

        2.   Stamens 3, spikelets 0·75 cm. long or longer.. . ...*C. compressus*

        2.   Stamen one, spikelets 0·6–0·8 cm. long........ ... *C. aristatus*

*Cyperus compressus Linn. Sp. Pl. ·68 (1753) ; FBI. 6,605 ; Duthie 2,384.

An erect herb upto 0·5 m. high, with base of stem covered by red purple fibrous leaf-sheaths. Spikelets compressed laterally, 4 to 7 in each ultimate umbellate spikes ; greyish-green, streaked with red ; stamens 3 ; nut broadly triquetrous, obovoid with 3 angled and 3 concave sides.

It grows in wet places and near the ponds and drains. Flowering and furiting during August to October.

C. C. Garden, *Panigrahi* 3867 and 4741.

*Cyperus iria Linn. Sp. Pl. ·45 (1753) ; FBI. 6,606 ; Duthie 2,385.

Annual herb growing upto 0·75 m. high with one to many flowering stems. Leaf sheaths brown or reddish brown. Inflorescence a compound umbel ; with 0·75 cm. long or longer spikelets ; flowering glume broadly boat shaped ; 2–5 nerved with nerveless wings ; stamens 2 ; nut triquetrous, ellipsoid, dark brown.

It grows in wet places in gardens fields and on the edges of ponds. Flowers and fruits during July to October.

Chatham Lines, *Panigrahi* 3879 ; *V. N. Singh* 908.

*Cyperus iristatus Rottb. Deser. et. Ic. 23, t. 6 (1753) ; FBI. 6,606 ; Duthie. 2,385.

An annual herb upto 20 cm. high, lower part of the stem covered by glabrous sheaths, with transversely truncate mouth. Inflorescence an umbellate spike, dense, about 1·5 to 2 cm. long, spikelets 0·6 or 0·8 cm. long ; stamen one; nut smooth, brownish and narrowly obovoid.

Grows on moist places in gardens, road sides and shady places. Flowers and fruits from August to November.

Chatham Lines, *Panigrahi* 3880 ; 4708 and 475.

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INTERACTION OF AMINO ACIDS AND ORGANIC ACIDS FOR THE PRODUCTION OF THE FUNGISTATIC SUBSTANCE BY *STREPTOMYCES GRISEUS* AGRA STRAIN

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Introduction

A new strain of *Streptomyces griseus* identified as Agra strain has been isolated from soil of Agra and was found to be antagonistic to *Alternaria solani* and a few other fungi and bacteria (Basu Chaudhary 1964). The effect of different nutritional factors on the production of the fungistatic substance by the organism has been studied and was found that glucose, alanine and glutamic acid, malic and citric acids formed the best sources of carbon, nitrogen and organic acid supplements respectively with pH 7·0 as the optimum for the production of the active substance (Basu Chaudhary 1958, 1961, 1962 *a, b*). Spilsbury (1948) studied the effect of trace minerals and nitrogen sources and their interaction on the production of streptomycin by *Streptomyces griseus* and observed that tryptophane is essential in the early stages of development. As the nutrients behave in a different way when used in combination, it was considered desirable to study the effect of these optimum nutritional factors in combination with each other on the production of the fungistatic substance and the results thus obtained has been presented in this paper.

Method and Material

Streptomyces griseus Agra strain was cultured in 30 ml. of the medium contained in 250 ml. flask. Nutrient factors in the following four combinations were taken in the light of observations on individual factors :

Medium "A" : Glucose 8%, alanine 4%, malic acid 1%

Medium "B" : Glucose 8%, alanine 4%, citric acid 1%

Medium "C" : Glucose 8%, glutamic acid 4%, malic acid 1%

Medium "D" : Glucose 8%, glutamic acid 4%, citric acid 1%.

Only these nutrient factors were selected for interaction studies which have given optimum fungistatic activity. The rest of the constituents of the medium were : dipotassium phosphate 0·5 gm., and magnesium sulphate 0·25 gm., per litre of distilled water. The pH in all the four combinations was adjusted at 7·0 before autoclaving. The Media were sterilized at 10 lbs. pressure for half an hour and then inoculated with spore suspension of *Streptomyces griseus* Agra strain and incubated at 25°C. The fungistatic potency was measured on 7th, 10th, 13th and 16th day in terms of Serial Dilution Unit ('SD' Unit) as given by Brian *et al.* (1945). Five replicates of each treatments were maintained.

Results

TABLE 1

Showing the effect of main factors as well as their interaction in terms of 'SD' Units

Medium	DAYS				Mean	C.D.
	7	10	13	16		
"A"	6·4	12·8	32·0	64·0	28·8	
"B"	8·0	16·0	28·8	28·8	20·4	6·2
"C"	16·0	57·6	115·2	356·0	136·2	
"D"	9·6	19·2	51·2	128·0	52·0	
Mean	10·4	26·4	56·8	144·2		

C.D. for Interaction = 12·4

The influence of main factors as well as their interaction is significant. Studying the effect of four kinds of nutrition irrespective of number of days the fungistatic potency is maximum in nutrition "C" and minimum in nutrition "B". It is of intermediate category in nutrition "D" and "A" respectively. Nutrition "C" appears to be very much suitable for the production of the fungistatic substance as its figure is many times more than the others.

Considering the effect of age of the culture irrespective the type of nutrition, the figure indicates that with the advancement in age of the culture the fungistatic potency also increased from 7th to 16th day in medium "A", "C" and "D".

Discussion

For the production of any substance during biological fermentation, the constitution of the medium plays an important role. By replacing one constituent with another or a particular constituent in the presence of another affects the production of the desired substance.

In this experiment such a change has been observed with respect to nitrogen sources. When alanine and glutamic acid were tested (Basu Chaudhary 1962 *a*) as possible sources of nitrogen the amount of the fungistatic substance produced was the same in both the cases. But these sources when tested in presence of organic acids the production differed. In presence of malic acid the production of the fungistatic substance on the 16th day in the medium having glutamic acid as nitrogen source was 356·0 'SD' units and with alanine it was only 64·0 'SD' units. In presence of citric acid, glutamic acid gave only 128·0 'SD' units and alanine 28·8 'SD' units. Further, the behaviour of the individual nitrogen source was also found to differ in presence of different organic acids. Glutamic acid in the presence of malic acid gave 356·0 'SD' units and in the presence of citric acid only 128·0 'SD' units. Similar is the case with alanine.

The effect of organic acids in interaction is the same as observed individually.

Summary

The interaction of amino acids indicate that the utilization of nitrogen source is influenced by the presence or absence of organic acids and also the type of acid present in the medium.

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OBSERVATIONS ON INDIAN AQUATIC FUNGI
III. SOME SPECIES OF BLASTOCLADIALES, MONOBLEPHARIDALES AND PERONOSPORALES COLLECTED FROM GORAKHPUR

By

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Gorakhpur with all its ponds and natural water reservoirs is an interesting place for the investigation of aquatic fungi. During the past three years a systematic collection of fungi particularly members of the lower phycomycetous orders have been undertaken by the senior author and his students. In the present investigation several aquatic phycomycetes were obtained from water and soil samples in the vicinity of Gorakhpur. Though none have been described earlier from this area, three of them viz. *Allomyces neo-moniliformis*, *Pythium ultimum* and *Phytophthora gonapodyides* are new records from India. Among Indian workers systematic study on water molds was made by Butler (1907 and 1911), Chaudhuri and Kochhar (1935), Chaudhuri and Lotus (1936), Saksena and Bhargava (1944), Das Gupta and John (1953), Ramdayal (1958) and Saksena and Rajagopalan (1958).

Material and Methods

The usual methods of setting baits were employed and wire baskets were used as bait containers. Various fruits and twigs were used as baits. Apples, tomatoes, grapes and cape gooseberries were found most satisfactory baits for *Blastocladia*, paniyala fruit (*Bischofia javanica*) for *Gonapodya* and cape gooseberry (*Physalis peruviana*) for *Phytophthora*. For *Pythium* and *Allomyces* water and soil samples were poured into Petridishes and baited with halves of hemp seed. After 3 days mycelial growth became visible, sporangia developed and within 1-2 weeks sex organs were formed. Pure cultures of *Allomyces*, *Pythium* and *Phytophthora* were obtained by methods recommended by Couch (1939) and Emerson (1958). Among the members of Blastocladiales and Monoblepharidales only *Allomyces* was grown in pure culture and others were preserved in 0·5% formaline.

FUNGI COLLECTED

Blastocladiaceae

Blastocladia Pringsheimii, Reinsch, Jahrb. Wiss. Bot. 11 : 298, 1878.

Thallus 570-715μ ; basal cell variable in size 250-420 × 70-105μ, generally cylindrical with swollen lobes on its distal part ; zoosporangia 70-150 × 15-30μ not proliferating, empty sporangia remain intact for a long time ; zoospores spherical or ovoid, 7-13·8μ in diameter ; long setae present. The fungus was smaller in all respects than the original description of Reinsch. This species, the most abundant of all other molds, was many times isolated from waters of Rapti river, Ramgarh lake and University garden pond on apple, grape, cape gooseberry and tomato baits (Fig. 1-A).
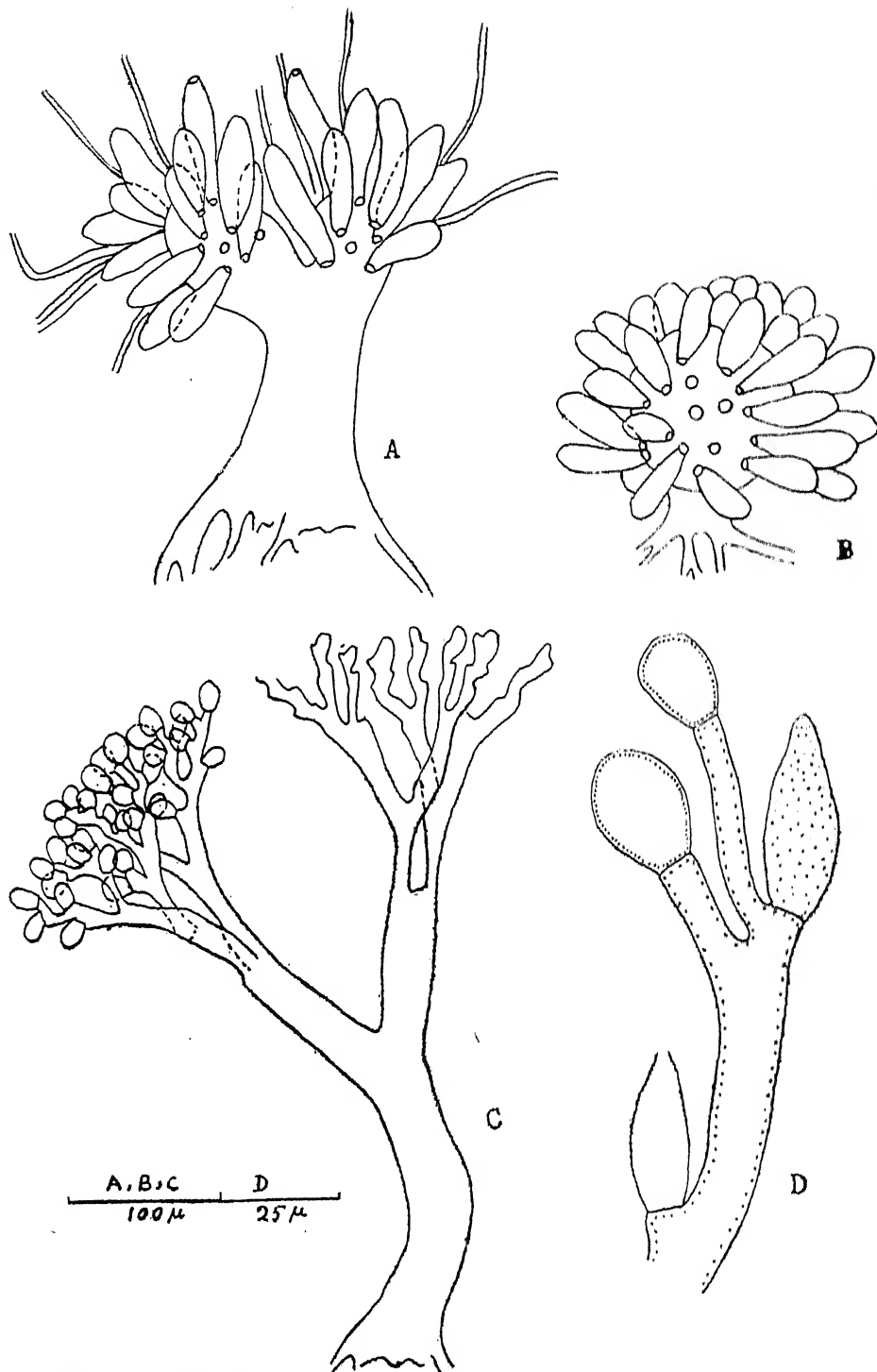
Fig. 1. A. *Blastocladia Pringsheimii* plant bearing setae, zoosporangia and rest-
ing spores. B, *B. globosa*, plant with spherical basal cell and zoosporangia.
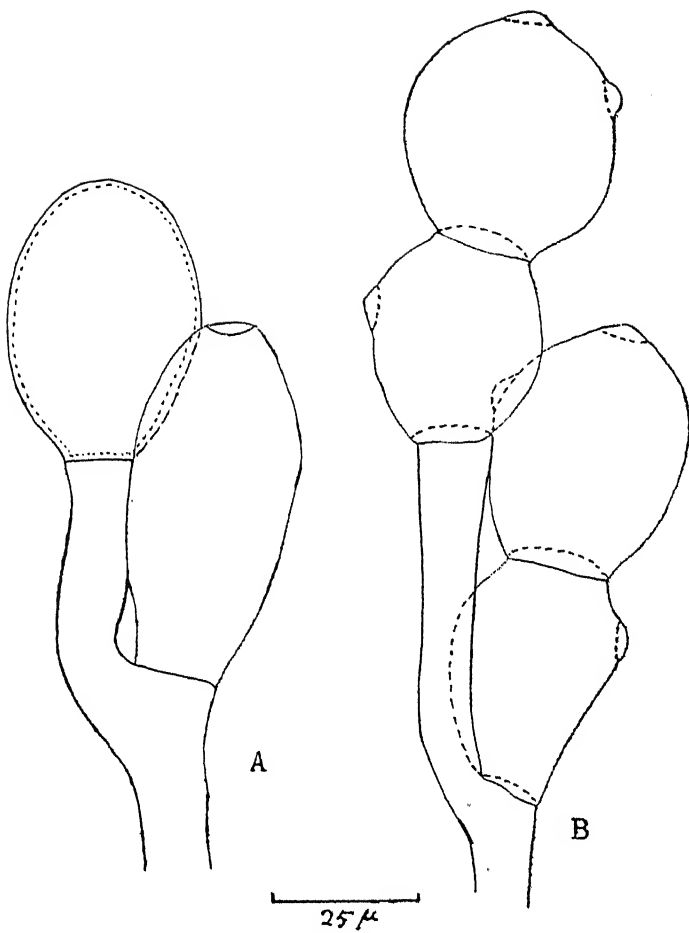C-D, *B. ramosa*: C, habit of plant showing zoosporangia.

Fig. 2. A–B, *Allomyces arbuscula* : A, mature resting and an empty zoosporangium. B, portion of gametophytic plant with male gametangium hypo- and female epigynous.

Blastocladia globosa Kanouse, Amer. J. Bot. 14 : 298, 1927.

This species was readily distinguishable by its globose basal cell, absence of proximal part and presence of strong rhizoidal system ; thallus 200–360μ ; proximal cylindrical part very short and 30–35μ in diameter or absent ; zoosporangia clavate, 66–130μ long by 15–35μ in diameter ; setae absent ; resting spores not observed. It was common in Ramgarh lake and garden pond waters and appeared very early on fruit baits mentioned above (Fig. 1-B).

Blastocladia ramosa Thaxter, Bot. Gaz. 21 : 50, 1896.

Plants with an open ramose habit 500–780μ, branching di- or subdichotomous ; zoosporangia 35–52×14–20μ, zoospores pyriform, 4·5–7μ in diameter ; resting spores 25–32μ × 23–26μ ; thallus with a weak hold fast system. This species takes a longer time than the other two species mentioned above to appear on apple and grape baits and has been recorded from Rapti river, Ramgarh lake and garden pond waters (Fig. 1 C and D).

Allomyces arbuscula E. J. Butler, Ann. Bot. London, 25 : 1027, 1911 Emend. Hatch, J. Elisha Mitchell Sci. Soc. 49 (1) : 163, 1933.

Plants large in size, hyphae pseudoseptate ; zoosporangia hyaline with distinct discharge papillae ; encysted zoospores 9–11·5μ in diameter ; resting spores 30–40μ wide ; sex organs borne in pairs, male gametangia hypogynous, bright orange in colour 20–35μ × 18–30μ, female gametangia hyaline 28–40×30–40μ. It is most common member of the genus and was several times isolated from water and soil of Ramgarh lake and garden pond on hemp seed bait (Fig. 2 A and B, plate I A).

Allomyces neo-moniliformis, Indoh, Sci. Rept. Tokyo Bunrika Daigaku, Sect. B. 4 : 271, 1940.

Syn. *Allomyces cystogenus* var. *cystogenus* Emerson, Lloydia, 4 : 136, 1941.

Life cycle cystogenus type ; plants large in size ; zoosporangia 45–96·2×23–34·5μ, secondary zoosporangia borne in long chains ; encysted zoospores 10–12μ in diameter ; resting spores with rounded apex 40–69×30–50·5μ averaging 54μ in length and 40μ in width, planonts from resting spore 9–12μ in diameter giving rise to 4 isogamous gametes which fuse in pairs. Fungus was isolated from soil of Ramgarh lake on hemp seed bait (Plate 1 B).

Gonapodyaceae

Gonapodya polymorpha Thaxter, Bot. Gaz. 20 : 481, 1895.

Hyphae 7–11·5μ, segmentation of hyphae distinct, may be indistinct in long slender portions of the hyphae ; sporangia internally proliferous, 30–95×18–30μ, variable in shape and size, long oval to tapering abruptly to a blunt tip ; zoospores 7–11·5×3–5μ. The fungus has been several times isolated from waters of Ramgarh lake, garden pond and Rapti river on a wide range of fruit baits with pronounced preference towards paniyala fruit (*Bischofia javanica*) (Plate I C).

Gonapodya prolifera (Cornu) Fischer, Rabenhorst. Kryptogamen-Fl. 1 (4) : 832, 1892.

Plants similar to *G. polymorpha* except very long pod shaped sporangia upto 200μ mostly 80–150μ. Fungus was common on apple, grape, tomato and paniyala fruit baits in waters of Ramgarh lake and garden pond.
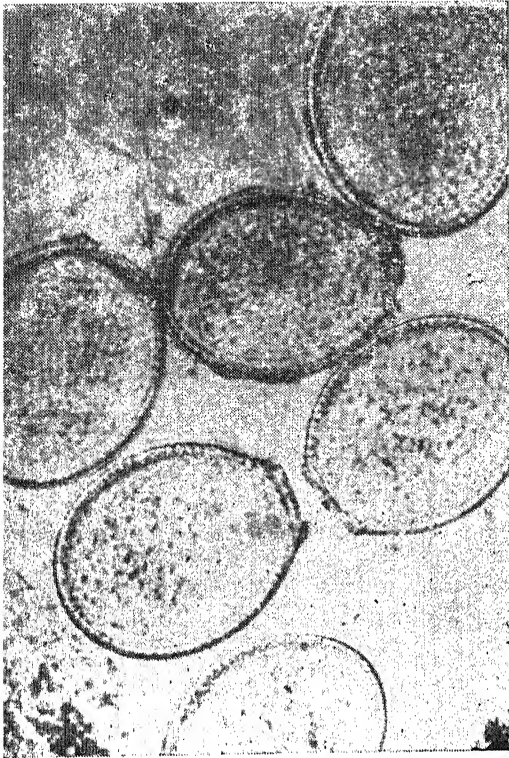
Allomyces arbuscula : mature resting spores. X850
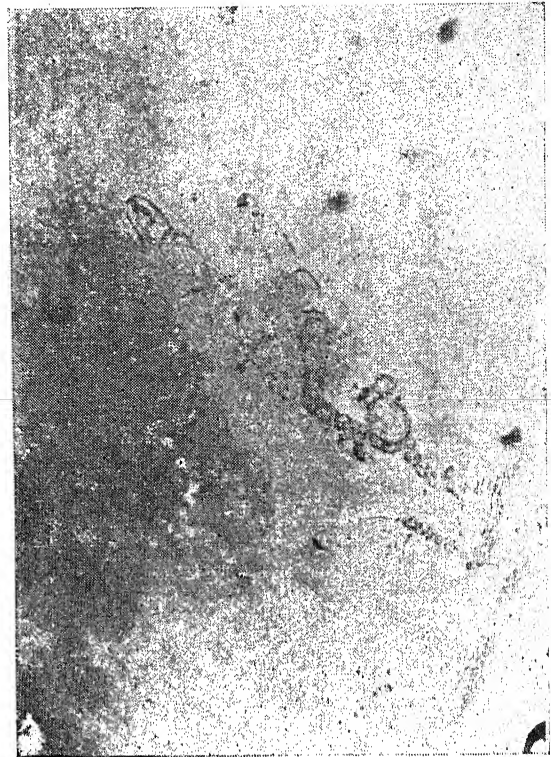
B. *Allomyces neo-moniliformis* : long chains of zoosporangia. X140.

C. *Gonapodya polymorpha* : branched hyphae bearing proliferating sporangia, some of them are discharging their spores. X200.
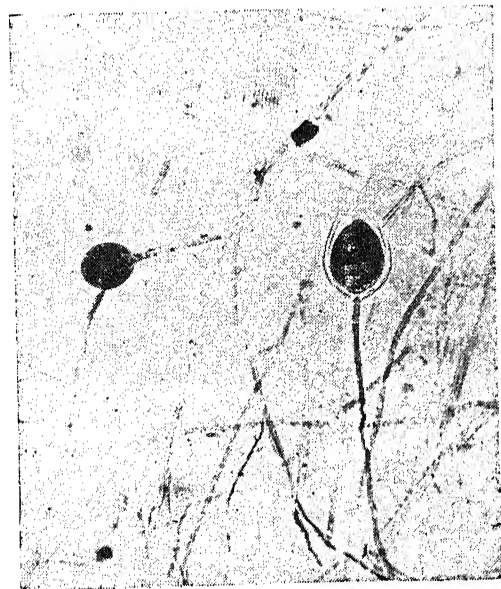
D. *Phytophthora gonapodyides* : branched hyphae and sporangiophore with proliferating limoniform sporangium, a mature ovoid sporangium is also lying near the proliferating one. X220
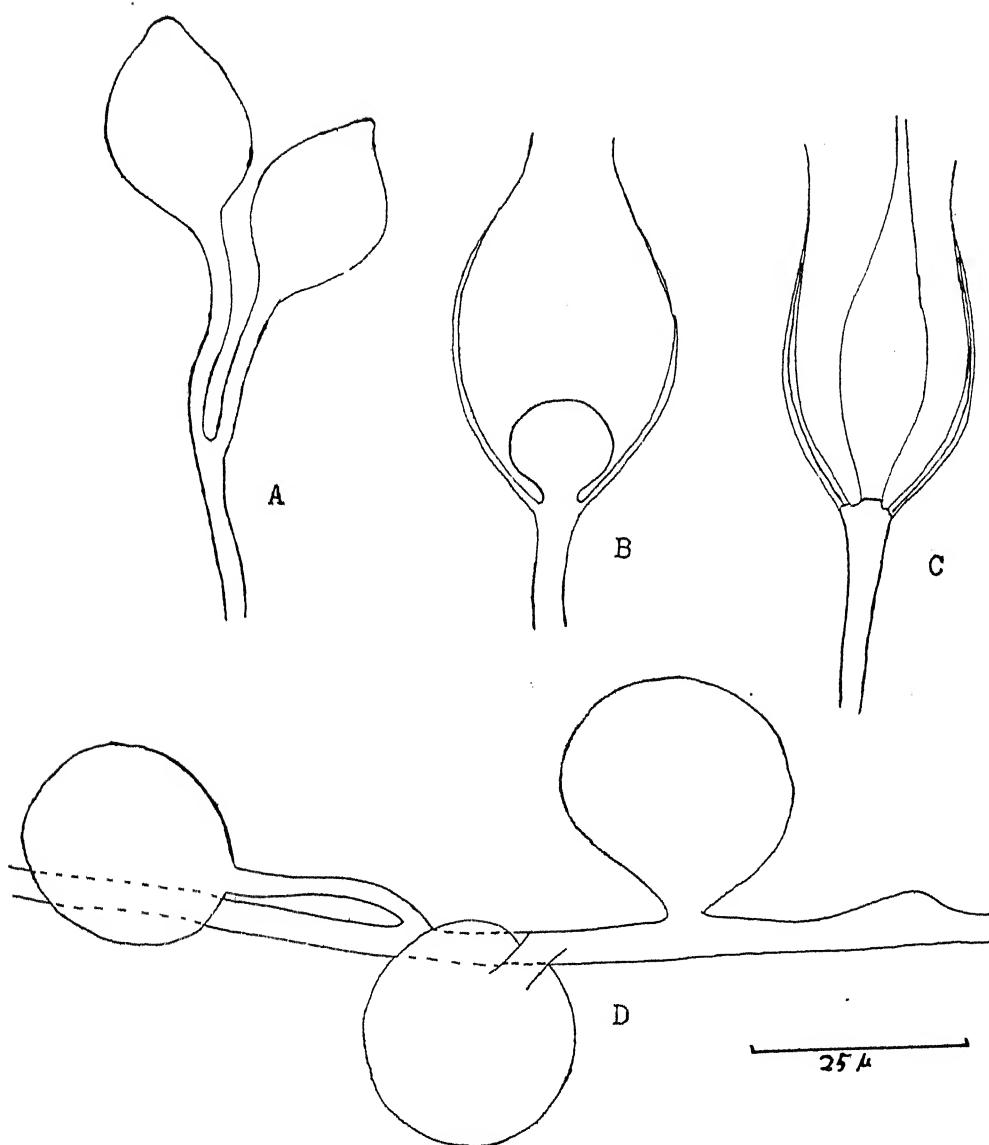
Fig. 3. A-D, *Phytophthora gonapodyides*. A, two young sporangia. B-C, proliferating sporangia. D, abnormal swhyphal cllings.

25μ
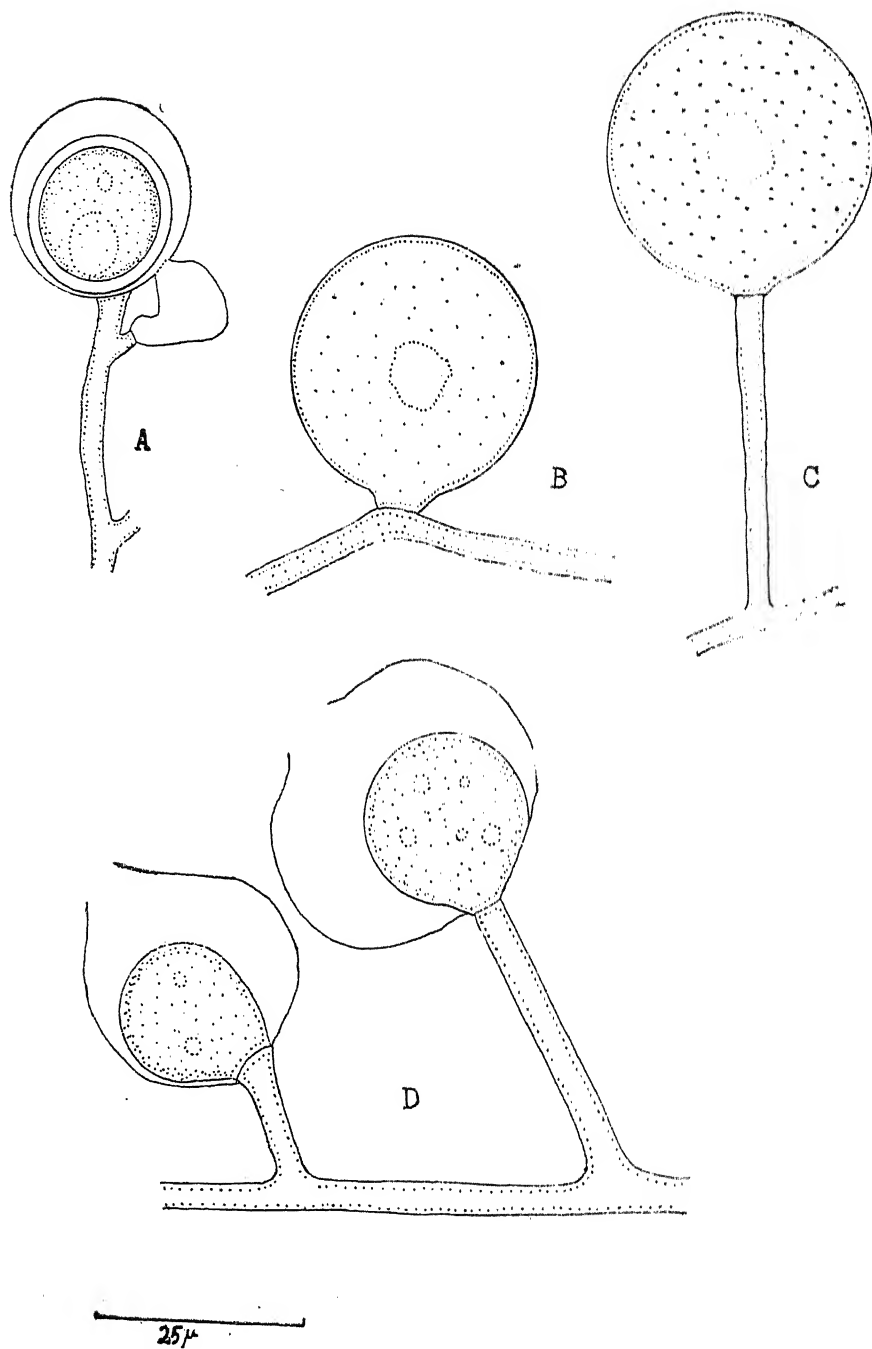
Fig. 4. A-C, *Pythium ultimum*. A, oogonium with monoclinous antheridium from immediately below. B-C, spheroidal sporangia. *D. Pythium carolinianum* : proliferating sporangia.

Pythiaceae

Phytophthora gonapodydies (N. E. Petersen) Buisman, Meded. Phytopath. Lab. Scholten, 11 : 7, 1927.

Mycelium 3–8μ in diameter bearing spherical, ellipsoidal or irregular hyphal swellings 11·5–35μ, protoplasm refractive ; zoosporangia ovoid to limoniform with a blunt apex, 40–50×35–40μ, capable of renewed growth by internal proliferation of secondary sporangium, sessile or stalked within the primary one ; zoospores are completely formed inside the sporangium, 9·2–14μ in diameter. The fungus was common in garden pond water on cape gooseberry and grape baits (Fig. 3, A–D and Plate I, D).

Pythium ultimum Trow, Ann. Bot. 15 : 269, 1901.

Sporangia spherical 20–40μ in diameter, often germinating by germ tubes ; oogonia smooth 16–21μ in diameter, antheridia 1–2 per oogonium, monoclinous from immediately below the oogonium, curved ; oospores aplerotic, single, thick walled 13·5–18·5μ in diameter. The fungus was isolated from water and soils of Ramgarh lake, Rapti river and garden pond on hemp seed bait (Fig. 4 A–C).

Pythium carolinianum Matthews, Studies on genus *Pythium* 1931, Univ. N. C. Press, Chapel Hill.

Sporangia spherical, subglobose to obovate with a distinct apical papilla, 25–50×20–40μ, proliferating through empty ones ; zoospores 7–10μ in diameter, formed inside the vesicle 30–50μ in diameter ; sex organs absent. It was recorded on vegetable debris by Balakrishnan (1948). Here it has been recorded from water and soils of Ramgarh lake and garden pond on hemp seed bait (Fig. 4 D).

Summary

The study was made of aquatic phycomycetes occurring in soils and water of Gorakhpur. The following members belonging to Blastocladiales, Monoblepharidales and Peronosporales were recorded.

Blastocladia Pringsheimii, B. globosa, B. ramosa.

Allomyces arbuscula.

A. neo-moniliformis.

Gonapodya polymorpha, G. prolifera.

Phytophthora gonapodyides.

Pythium ultimum and *P. carolinianum.*

Among the fungi collected *Allomyces neo-moniliformis, Phytophthora gonapodyides* and *Pythium ultimum* are new records from India.

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*Original not seen.

ECOLOGICAL STUDIES IN CONVOLVULUS PLURICAULIS LINN. WITH SPECIAL REFERENCE TO REPRODUCTIVE CAPACITY IN RELATION TO GRAZING

By

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A large number of grassland areas surround the buildings within the campus of Banaras Hindu University, Varanasi. These are of different size, and some of them are fenced and others are open to grazing, trampling and scraping. It is possible to differentiate protected, mediumgrazed and overgrazed fields (Sant, 1963). It is interesting to investigate ecology of *Convolvulus pluricaulis* with special reference toreproductive capacity from different grazing grounds of Varanasi.

The experimental areas under present investigation lies in the Upper Gangetic plains and are situated on the level grounds near the West bank of the Ganges about three miles to the south of Varanasi, which lies at 28° 18′ north latitude and 83° 1′ east longitude. It is approximately 76·19 meters above the sea level.

PHYTOSOCIOLOGICAL STUDIES

Frequency

The seasonal frequency distribution of *Convolvulus pluricaulis* along with the important associates from different grazing grounds are given in table 1.

TABLE I

Seasonal percentage frequency distribution of Convolvulus pluricaulis along with the important associates from different grazing grounds

Plant species	Protected field			Mediumgrazed field			Overgrazed field		
	*S	*R	*W	*S	*R	*W	*S	*R	*W
Alysicarpus longifolius	0	78	0	0	60	0	0	29	0
Boerhaavia diffusa	25	24	31	40	35	36	53	45	38
Bothriochloa pertusa	0	92	50	0	78	21	0	32	20
Crotalaria medicaginea	20	65	6	10	58	0	0	78	0
Convolvulus pluricaulis	80	7	51	60	4	50	83	12	72
Cynodon dactylon	50	48	48	83	61	62	35	70	66
Dactyloctenium aegyptium	0	20	0	0	23	0	0	39	14
Desmodium triflorum	70	83	76	70	67	57	43	53	46
Dichanthium annulatum	100	18	86	100	39	86	76	10	47
Digitaria sanguinalis	0	30	0	0	37	0	0	44	0
Echinochloa colona	0	18	0	0	31	0	0	28	0
Evolvulus alsinoides	40	31	28	60	54	55	83	75	61
E. nummularius	45	26	35	60	67	55	90	84	82
Indigofera linifolia	65	88	87	80	40	33	37	19	9
Panicum psilopodium	0	50	0	0	54	0	0	73	0

*S = summer season ; *R = rainy season and *W = winter season

According to the intensity of grazing there is a general increase or decrease in frequency of the species in each of the season. As per data given in table I, it is possible to classify the species into 'increasers', 'decreasers' and 'neutrals' according to their frequency distribution in response to grazing. The ecological behaviour of *Convolvulus pluricaulis* from different grazing grounds during different seasons shows that its population has a balancing capacity against grazing and protection *i.e.*, it is a 'neutral'.

Coverage

The variations in coverage of this plant species under the influence of grazing have been taken into consideration. The vegetation was charted in meter quadrats to know the actual position of each plant species upon the field during the summer and the rainy seasons. Although this method proved to be laborious, yet it gave exact quantitative results. Various charts were taken from different grazing grounds during summer and rainy seasons.

From each chart the area of *Convolvulus pluricaulis* along with other important plant species is noted and the averages are taken for each species from various charts per field. Then the averages of each species per meter quadrat per grazing field is computed and given in table II.

TABLE II

Average area occupied by C. pluricaulis along with the important associates from different grazing grounds

| Plant species | Average area occupied by the plants in square cm. per meter quadrat | | | | | |
| | Protected field | | Mediumgrazed field | | Overgrazed.field | |
	*S	R	*S	*R	*S	*R
Alysicarpus longifolius	–	0·968	–	1·237	–	1·24
Boerhaavia diffusa	1·14	1·412	1·042	2·76	2·01	2·16
Bothriochloa pertusa	–	2·69	–	4·61	1·86	5·66
Convolvulus pluricaulis	1·98	1·0	7·17	2·43	1·73	3·06
Crotalaria medicaginea	–	4·59	–	1·89	–	1·87
Cynodon dactylon	2·10	1·11	3·81	3·17	6·204	3·01
Dactyloctenium aegyptium	–	3·52	–	2·63	–	2·54
Dichanthium annulatum	3·06	1·79	6·13	3·57	2·18	2·04
Digitaria sanguinalis	–	1·08	–	3·78	–	1·8
Euphorbia hirta	–	–	3·08	0·77	–	1·82
Evolvulus alsinoides	1·82	1·04	2·9	2·72	2·1	1·5
E. nummularius	0·68	3·22	2·11	4·502	2·28	2·421
Indigofera linifolia	1·596	4·17	3·16	3·34	1·50	3·13

*S = summer ; *R = rainy season

It is concluded from the table II that the coverage of this plant is proportional to the moisture supply—being maximum in rainy season—the coverage increases due to higher availability of moisture which plays an important role in the growth of the plant. The grazing decreases the coverage of this plant.

Grazing Susceptibility Number

Dix (1959) has evolved a method by which the behaviour of each species under grazing pressure can be objectively estimated. According to him when the grazing susceptibility number is negative in both the stands it indicates that the species are capable of withstanding moderate and severe grazing, and if this number is positive in both the stands the species are hamperd or at disadvantage under the grazing. The charged quadrats in different grazing fields were used to find the density of *Convolvulus pluricaulis* and its important associates per unit area (Sant, 1961). Thus in this case the density is found out directly by actual counting which is always better (Sant, 1964) than deriving it from frequency data as done by Dix (1959). The grazing susceptibility number is calculated by the following formula :

$$\text{Grazing susceptibilty number for species} = \frac{\text{Sum densities protected} - \text{Sum densities mediumgrazed OR overgrazed}}{\text{Sum densities protected (when numerator is positive)} \quad \text{Sum densities mediumgrazed OR overgrazed (when numerator is negative)}} \times 10$$

The grazing susceptibility number calculated by the above formula, there-fore, indicate the relative changes in the densities of a species on account of grazing. These numbers as calculated for the different grassland species in the protected and mediumgrazed, and protected and overgrazed stands are given in table III.

TABLE III

Grazing susceptibility number for Convolvulus pluricaulis and some important associates from different grazing grounds

Plant species	Grazing susceptibility number in protected-mediumgrazing fields				Grazing susceptibility number in protected-overgrazed fields			
	Summer		Rainy		Summer		Rainy	
	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
Alysicarpus longifolius	—	—	2	—	—	—	1·9	—
Boerhaavia diffusa	—	3	—	9·1	—	4	—	8·0
Bothriochloa pertusa	—	—	2	—	—	—	6	—
Convolvulus pluricaulis	—	1·3	—	3	—	3	—	5·8
Crotalaria medicaginea	—	—	—	1·1	—	—	—	6·7
Cynodon dactylon	—	3	—	7	—	4	—	9
Dactyloctenium aegyptium	—	—	—	4	—	—	—	6·2
Dichanthium annulatum	2	3	3·3	—	8·4	—	9·4	—
Digitaria sanguinalis	—	—	—	3·3	—	—	5	—
Euphorbia hirta	—	—	—	3	—	—	—	5
Evolvulus alsinoides	—	2	—	2	—	3	—	2·2
E. nummularius	—	2·3	—	3	—	7	—	8
Indigofera linifolia	4·	—	8·3	—	7·2	—	9·0	—
Panicum psilopodium	—	—	3	—	—	—	2	—

It is seen from the table III that the grazing susceptibility number of *Convolvulus pluricaulis* is negative in both the stands *i.e.*, the species is capable of withstanding moderate and severe grazing.

Phenology

Convolvulus pluricaulis is a perennial and resumes its activity by seeds which germinate in the month of July. Flowering starts in the month of August and fruiting starts in the month of September both continuing upto the month of April and May. The plant gets dried up in the last week of May.

Seed Character

The seed characters of *Convolvulus pluricaulis* from the different grazing grounds are given in table IV.

TABLE IV

Seed dimension, seed shape index (length/breadth ratio), seed weight and seed density of Convolvulus pluricaulis

Locality	Season	Seed dimension		Seed index (L/B)	Av. seed weight in mg.	Seed density
		Av. length in μ	Av. breadth in μ			
Protected field	Rainy	1950 ±80·2	1170 ±70·5	1·7	10·5	0·155
	Summer	1959 ±81·6	1191 ±77·6	1·6	12·0	
Mediumgrazed field	Rainy	1750 ±40·0	1019 ±46·0	1·7	2·0	0·122
	Summer	1751 ±40·0	1019 ±46·6	1·7	1·4	
Overgrazed field	Rainy	1860 ±75·11	1218 ±116·3	1·5	12·0	0·163
	Summer	1878 ±76·2	1224 ±118·2	1·5	14·0	

The seeds are globose, dark coloured. The seed size is not affected by the season, although the dry season invariably produces heavier seeds. The grazing affects both size and the weight of the seeds in both the seasons, although the volume remains more or less the same with length and breadth bearing reciprocal relationships. The seeds are heavier in the overgrazed field.
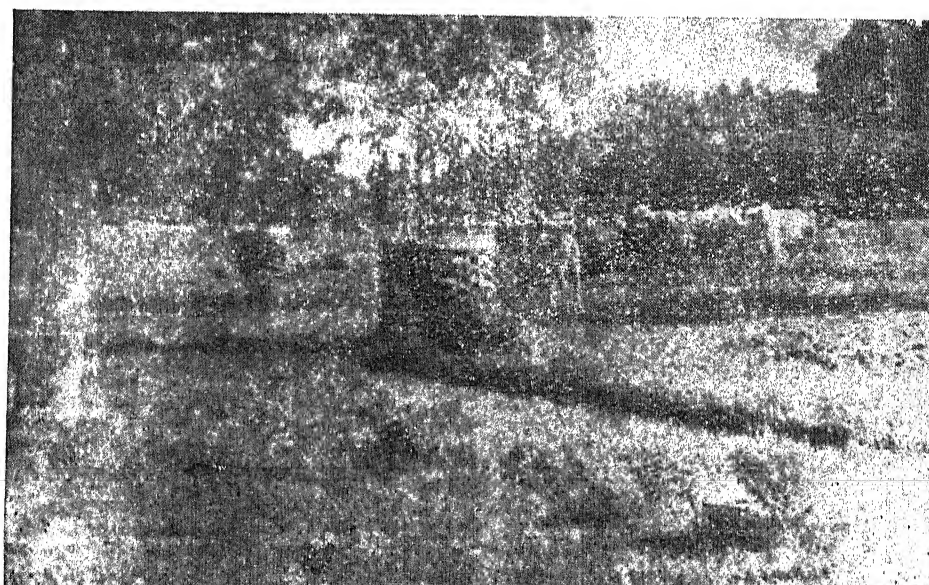
Fig. 1. Grazing ground showing the grazing by animals.
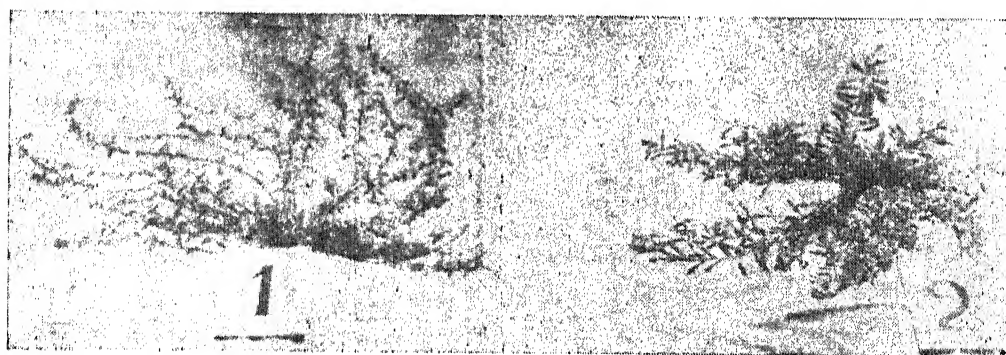

Fig. 2. *Convolvulus pluricaulis* showing variation in growth form in relation to grazing intensities.

1 = Representative from protected field ...... X 1/10 (approx.)
2 = Representative from overgrazed field ..... X 1/8 (approx.)

Seed Output

The average seed output data along with the standard deviation for *C. pluricaulis* from different grazing grounds during summer and rainy seasons are given in table V. The averages for seed output of this plant were determined by taking 90 plants from each type of grazing field, and for the averages of seeds per fruit 270 fruits of each species were taken for each type of fields.

TABLE V

Seasonal seed output of Convolvulus pluricaulis from different grazing grounds

Locality	Av. no. of fruit/plant		Av. no. of seeds/fruit		Av. seed output		Av. seed output for each grazing ground	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Protected field								
(a) Opp. Botany Dept.	467 ±10·0	123 ±6·5	2 ±0·6	2 ±0·66	934	256		
(a) Behind Mining college	1518 ±620	–	2 ±0·6	–	3036	–	2224	256
(c) Behind Indology college	1350 ±560	–	2 ±0·6	–	2700	–		
Mediumgrazed field								
(a) Opp. Birla Hostel	196 ±40·3	85 ±18·2	2 ±0·5	2 ±0·07	392	170		
(b) Opp. Aiyar Hostel	257 ±49	81 ±21·0	2 ±0·6	2 ±0·07	514	162	436	191
(c) Near Agri. Farm	201 ±60·0	121 ±10·6	2 ±1·0	2 ±0·72	402	242		
Overgrazed field								
(a) Opp. Ruiya Hostel	148 ±25·8	149 ±20·4	2 ±0·6	2 ±1·2	296	298		
(b) Opp. Rajputana Hostel	252 ±30·8	119 ±28·9	2 ±0·7	2 ±1·0	504	238	317	254
(c) Opp. Science college	174 ±28·9	91 ±30·5	2 ±0·06	2 ±0·50	348	182		
(d) Near Central office	165 ±30·2	149 ±85·6	2 ±0·50	2 ±0·48	330			

From the above table it is observed that the average seed output is minimum in the overgrazed field and maximum in the protected during the summer season. However, it is minimum in the mediumgrazed field during the rainy season, but maximum in the protected field.

Germination

Seeds of *Convolvulus pluricaulis* were collected during summer and were kept for germination in the same season and also during rainy season in between two moist filter paper in a Petri dish for a month. The germination data are given in table VI.

[65]

TABLE VI

Germination of seeds of Convolvulus pluricaulis from the different grazing grounds

Locality	Percentage germination	
	Summer	Rainy
Protected field	34	36
Mediumgrazed field	27	34
Overgrazed field	31	40

The observations given in the above table shows that the percentage germination is higher in rainy season in all the grazing fields. The seeds have no dormancy and germinate under normal conditions.

Reproductive Capacity

Convolvulus pluricaulis does not propagate by vegetative means. Sexual reproduction is calculated in terms of reproductive capacity for *C. pluricaulis*. Salisbury (1942) defined reproductive capacity as the product of average seed output and the fraction represented by the percentage germination. Reproductive capacity was estimated for two seasons, *i.e.* the summer and the rainy. The data are set in table VII and VIII. The table VII shows seasonal seed output, percentage germination and reproductive capacity. Table VIII shows reproductive capacity in different seasons as calculated by taking the maximum percentage germination recorded in the rainy season.

TABLE VII

Reproductive capacity of Convolvulus pluricaulis

Locality	%Germination		Av. seed output		Reproductive capacity	
	Summer	Rainy	Summer	Rainy	Summer	Rainy
Protected field	34	36	2224	257	756	93
Mediumgrazed field	27	34	436	191	117	65
Overgrazed field	31	40	370	254	115	111

TABLE VIII

Reproductive capacity of Convolvulus pluricaulis from different grazing grounds when the maximum % germination is taken

Locality	%Germination as in the rainy season	Av. seed output		Reproductive capacity	
		Summer	Rainy	Summer	Rainy
Protected field	36	2224	257	801	93
Mediumgrazed field	34	436	191	148	65
Overgrazed field	40	370	254	148	111

It is found from the above tables that the reproductive capacity is maximum in the protected field during both the seasons. In this case the plant thrives better during summer season when the vegetation is thin and the competition is less.

Seed Dispersal

Ridley (1930) describes dispersal in the family Convolvulaceae, as widely sea dispersed. In the seeds of Convolvulaceae the buoyancy is due to unoccupied space in the testa. As a rule the embryo fills the testa more or less incompletely and it is on the relative size of the unoccupied space that the sinking or floating depends. However, in the present case the question of sea dispersal does not arise. Hence wind helps to carry the seeds to short distances. Man unintentionally may carry the seeds with cut grass from the grazing grounds.

Ecology

The plant grows in different grazing grounds in open and sometimes under shade Fig 1. It also occurs on the roadside footpath, waste places, margin of drains etc. This plant withstands competition with grasses and other forbs. The plant is equally distributed in protected and overgrazed fields Fig 2.

Biotic Factor

It is subjected to various biotic factors such as grazing, trampling and scraping etc. The leaves are palatable and the plants are trampled by animals and men. It withstands high pressure on the grazing grounds where heavy iron rollers are used on the fields besides games being played every day.

Discussion

The seasonal reproductive capacity of *Convolvulus pluricaulis* from different grazing grounds has been examined. It is observed that the reproductive capacity decreases as the intensity of grazing is increased during both the seasons.

Convolvulus pluricaulis yield seeds in two seasons and the shape of the seeds is affected by grazing, although the volume remains more or less the same with length and breadth bearing reciprocal relationships. But the seeds are definitely heavier in the overgrazed fields. This plant produces better seeds on protection.

Thus it is seen that the effects of grazing on the reproductive capacity are varied. The nature, extent and frequency of damage caused to the different organs of the plant appear to set up a sequence of metabolic events where in reproductive growth assume different patterns in this plant. The population of *C. pluricaulis* is equally distributed in all the seasons in the protected and overgrazed fields. But the coverage increases as the moisture content of the soil increases in the rainy season even though grazing reduces it. The reason for its reduction is the destruction of the apical buds due to biotic disturbances. Taking into account the coverage and density of *C. pluricaulis* it is found to be a increaser. These terms were used by Weaver and Hansen (1941) and Kucera (1956) with reference to frequency distribution this plant is a neutral. The habit and the growth of this plant appears to be responsible for this discrepancy.

The density has been studied in terms of grazing susceptibility number as given by Dix (1959) for the summer and rainy seasons only. This number is negative for *C. pluricaulis* meaning thereby that the grazing is favourable for it in both the stands.

[67]

It is interesting to examine the reproductive capacity of the species in relation to grazing susceptibility number. The data indicate that *C. pluricaulis* which is favoured by grazing as indicated by its negative grazing susceptibility number but the reproductive capacity follows different trend. Here the reproductive capacity follows different trend. Here the reproductive capacity attains the maximum figure in the protected field and the reason for this reverse trend is because of the fact that the flower buds are eaten up and trampled over by the grazing animals in the overgrazed fields.

A discussion of the above facts leads to the conclusion that generally speaking biotic disturbances decreases the reproductive capacity of *Convolvulis pluricaulis*.

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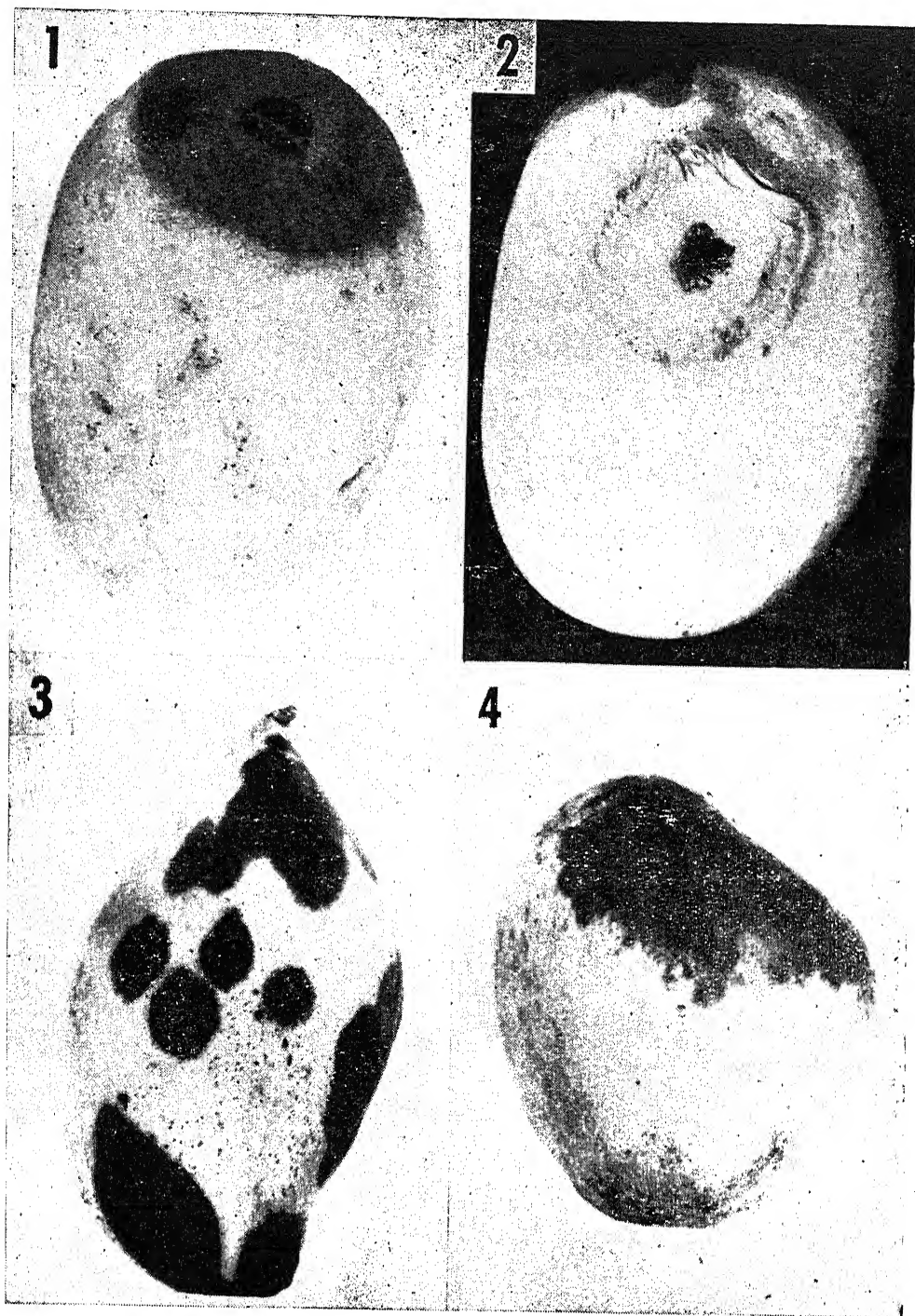
Fig. 1. Showing stalk-end rot of mango caused by *Aspergillus niger*.
Fig. 2. Showing lateral rot of mango caused by *A. niger*.
Fig. 3. Showing Colletotrichum rot
Fig. 4. Showing Botryodiplodia rot.

STUDIES ON FUNGAL DISEASES OF SOME TROPICAL FRUITS
III. SOME POST HARVEST DISEASES OF MANGO
(*MANGIFERA INDICA* L.)

By

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Introduction

Mango, the choicest fruit of India, is subjected to a wide variety of diseases caused by different types of organisms. Among them, fungi comprise the major group of pathogens responsible for fruit rot diseases. Recently Srivastava *et al.* (1964) have reported a number of fungi associated with different parts of the mango plants, but it has been ascertained that all of them were not pathogenic to mango fruits. It has further been observed that some of these organisms could attack mango fruits and may cause considerable damage to them in storage and market. The authors have surveyed the important mango growing tracts and fruit markets in India and have observed that the loss due to fungal infection in storage, transit and market ranges from 5 to 30%.

The three diseases of mango included in this paper are of common occurrence and have been reported from various places, but so far no detailed study, based on extensive survey of wide localities, has been undertaken.

The present paper includes detailed description of the diseases and the percentage of fruits infected with three pathogens.

Material and Methods

Methods of collection, isolation and purification were similar to those adopted by Srivastava *et al.* (1964). Morphology of the different organisms has been studied both under natural as well as cultural conditions. Either Asthana and Hawker's medium 'A' or Potato Dextrose medium was employed for cultural studies. Granger and Horne's (1924) method was used for testing the pathogenicity. In each case the percentage infection was calculated on the basis of atleast one hundred fruits.

Observations

The percentage loss due to the three pathogens to different varieties of mango fruits observed at various localities in the year 1964 has been recorded in the Table. The dates of observation have been given in the parentheses.

Aspergillus rot :

Symptoms :.

The disease usually appears at the stalk end of the fruit and is quite distinct from rots caused by other organisms. At first it appears as a light brown circular patch. The intensity of colour of the infected area depends upon the variety of the fruit and the stage of the disease. The lesion grows in a regular manner and forms large circular spot encircling the stalk. After three or four days the inflected region becomes sunken and at an advanced stage it becomes somewhat crumpled. The rot is soft in nature. Black conidial heads of the causal organism, *Aspergillus niger* van Tiegh, become distinct after five or six days (Fig. 1).

TABLE I
Showing percentage loss due to three fungi to different varieties of mango

Varieties	Aspergillus rot		Colletotrichum rot		Botryodiplodia rot	
	% loss	locality	% loss	locality	% loss	locality
1. *Alphanso*	8	Calcutta (May, 3)	6	Calcutta (May, 3)		
2. *Banganapalli*	8–12	Calcutta (May, 3)				
3. *Begumpasand*	9	Calcutta (May, 3)				
	4	Patna (April, 23)				
4. *Bombai*			8	Allahabad (June, 29)	12	Lucknow (July, 5)
					7·5	Calcutta (May, 3)
5. *Chausa*	12	Kanpur (May, 7)				
6. *Dashehari*	15	Allahabad (June, 23)	5	Allahabad (June, 23)	20	Allahabad (June, 23)
	8	Lucknow (July, 5)			6·5–8	Lucknow (July, 5)
7. *Gulabkhas*	8–15	Calcutta (May, 3)			8	Calcutta (May, 3)
	7–12	Allahabad (May, 28, 30)				
8. *Himsagar*	7–12	Allahabad (June, 17)	12	Calcutta (May, 8)		
9. *Krishnabhog*					8	Kanpur (July, 7)
10. *Langra*	22	Allahabad (June, 19)				
11. *Makhan*	7	Kanpur (July, 7)				
12. *Neelam*			9	Poona (October, 9)		
			9–12	Bombay (October, 14)		
13. *Pairi*	6	Calcutta (May, 8)				
14. *Rumani*			12	Poona (October, 9)		
15. *Safeda Lucknow*	35	Lucknow (July, 5)	8	Kanpur (July, 8)	20	Allahabad (June, 23)
	14	Kanpur (July, 8)			15	Lucknow (July, 8)
16. *Safeda Malihabad*	14	Allahabad (June, 24)	8	Calcutta (May, 6)		
	8	Kanpur (July, 8)	15	Allahabad (June, 23)		
17. *Totapari*	10–20	Allahabad (June, 19)			9	Patna (April, 29)
	15	Patna (April, 29)				

Besides, causing stalk-end rot *A. niger* also causes lateral rot (Fig. 2), tip-end rot, or a rot at any other place. In these cases the position of the lesions depends on the position of injury on the fruits. Sometimes the spots are irregular in shape and this might be due to different types of injury caused to the fruit. Morphological characters of the organism are similar to those described by Thom and Raper (1945).

While considering the losses in storage it is interesting to note that *A. niger* is known to grow both saprophytically and parasitically. The authors have isolated it from soils as well as dead or decayed twigs or leaves of different varieties of mango. This organism has also been isolated from apparently healthy as well as withered flowers of some varieties of mango, *viz.*, 'Dashehari' and 'Safeda Lucknow' from Kara (Allahabad) ; 'Dashehari', 'Makhan' and 'Taimuriya' from Malihabad (Lucknow) and 'Langra' from Varanasi.

This organism has also been found to cause damage to the fruits in plantation. During March–April, 1964, it was found to cause a dry "brown rot" of 'Alphonso', 'Taimuriya' and 'Sukla' varieties of mango while they were attached to plants at Sabour (Bhagalpur). At Krishnagar (West Bengal) it was observed that 'Krishnabhogbela' variety of mango was severely damaged by *A. niger* in the orchards. Besides being badly rotten a number of fruits had become mummified on account of loss of water. Many such fruits remained attached to the plants and were thus capable of supplying inoculum to the other developing fruits. It is thus clear that either Aspergillus rot appears quite early and damages fruits in plantations or the pathogen remains dormant and becomes responsible for post harvest decay of fruits at a later stage.

Colletotrichum rot :

The anthracnose of mango is very common and worldwide in occurrence. Mostly different workers have observed this disease on leaves, twigs and flowers etc.

McRae (1924) reported that in Madras, this disease was caused by a species of *Gloeosporium*. Stevens and Pierce (1933) and Uppal *et al.* (1934) observed that in Bombay it was due to *G. raciborskii* P. Henn. Later, Sattar and Malik (1939) recorded it from Punjab and identified the causal organism as *Glomerella cingulata* (Stonem) Spauld. and Schrenk (*Colletotrichum gloeosporioides* Penz.).

Isolations made by the authors from rotten fruits and infected leaves collected from different localities indicated that all the isolates obtained were morphologically identical to *Colletotrichnm gloeosporioides* Penz., except for the absence of setae.

Symptoms :

Circular, dark brown specks, appear on the surface of the fruits at an early stage. Subsequently they enlarge and coalesce to form large spots, irregular in shape and dark brown in colour. After five-six days the acervuli appear as small, salmon or dark coloured dot like bodies on the infected region (Fig. 3).

Morphological characters of the pathogen are similar to those described by Sattar and Malik (1939).

The above organism has been isolated from young as well as mature fruits attached to the plants, leaves, twigs and flowers from orchards situated in various places. It is, thus, evident that the orchards may supply the inoculum for the disease which may make appearance in storage or market.

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Botryodiplo lia rot :

Botryodiplodia theobromae causes a common post harvest disease of mango fruits which is of wide occurrence in India. The disease causes considerable loss during storage, marketing and transportation.

Symptoms :

The infection usually starts at the stalk end of the fruit and very rarely at other regions. It begins as a water-soaked lesion surrounding the stalk which increases and soon covers up about 1/3rd to 2/3rd of the fruit. At this stage the central part of the infected area acquires a dark brown colouration and is surrounded by a light brown peripheral zone, the irregular margin of which assumes a water-soaked appearance. Pycnidia develop at later stage of rot as minute bodies. The rot is soft in nature (Fig. 4).

Morphological characters of the causal organism, Botryodiplodia theobromae Pat., are similar to those described by Das Gupta and Zachariach (1945).

The authors have isolated B. theobromae form the infected leaves of 'Rushke gulsitan', 'Chausa' 'Dashehari' and 'Bombai' varieties of mango from Lucknow. It has also been found associated with twigs of 'Safeda' and 'Bombai' varieties at Lucknow and Sabour (Bhagalpur) and flowers of 'Fazli' at Allahabad and Rataul (Meerut).

Discussion and Conclusions

It would be evident from the above findings that the three important fungal diseases of mango fruits caused by *Aspergillus niger*. *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* cause considerable damage to mango crops in diverse localities.

Out of these three, Aspergillus rot was very commonly encountered in markets of almost every locality that has been surveyed and it appeared on a large number of varieties. The variation in percentage loss to different varieties as well as the differences in the same variety at different places may be due to a number of factors especially the environmental ones.

The association of these three fungi with other parts of mango plants suggests that the organisms may get associated with the fruits in the orchards and subsequently cause infection when they are kept in storage. Generally, it is a common practice to use mango leaves for packing the fruits. Association of infected leaves with the fruits during transportation may increase the possibilities of infection. It has been observed that mostly the injured fruits become exposed to the possibilities of getting infected with these pathogens. Hence, during harvest and in storage, injuries should be avoided as far as possible. Detailed investigations on the possible measures to minimize loss due to these pathogens are in progress.

Summary

Symptoms of three diseases of mango fruits caused by *Aspergillus niger* van Tiegh., *Colletotrichum gloeosporioides* Penz. and *Botryodiplodia theobromae* Pat. have been described. The approximate percentage loss caused by the three organisms at different places has been recorded. Suggestions have been given for minimising storage losses.

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EFFECT OF PRESOWING TREATMENT WITH MICRO-ELEMENTS ON THE GROWTH, YIELD AND LEAF COMPOSITION OF *HORDEUM VULGARE* L.

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Introduction

A review of the literature shows that enormous work has been done on the effect of application of macro-nutrients especially nitrogen, phosphorus and potassium at the time of sowing as well as at the various stages of crop develop-ment on the growth, yield and chemical composition of the plants. Compara-tively little work has been done in our country on the effect of the micro-nutrients on the above aspects, the importance of which is very great.

The object of the present investigation is to find out the effect of a few micro-elements—namely copper, zinc, manganese and their mixture on the growth, yield and composition as revealed by leaf analysis. Micro-elements are essential for various physiological activities and if available in optimum doses will enhance the growth and final yield of the plants.

Leaf analysis has been taken as a means of evaluating the nutritional status of the soil as well as the effect of the treatments with micro-elements before sowing on the uptake of nitrogen, phosphorus and potassium. Lagatu and Maume (1930), Thomas (1937) and others took diagnostic foliage as the basis of investigations on plant nutrition problems. Beauchamp (1942) has taken the leaf as an index of soil fertility on the one hand and of crop yield on the other hand. Ulrich (1952) in his review has also emphasized plant analysis as a physiological basis for assessing the nutritional requirements of plants. Alexander and Schmer (1954) also found definite relationship between yield of sugar beet and leaf analysis value. Ranjan and Das (1957), and Das (1958) have also emphasized leaf analysis as a basis of plant nutrition studies.

Experiments with presowing treatments are relatively few in number. Doyle *et al.* (1952) found that potassium nitrate has pronounced and varied effects on germination, growth and development of a number of plants under presowing treatment. Mukherji and Mandal (1956) also found that ammonium sulphate has pronounced effects on germination and development of the plants. Zhezhel and Yardya (1956) have advocated that it is good cultural practice to apply micro-nutrients under presowing treatment. Voykin (1957) and Guttay (1957) studied the effect of phosphate on the germination, growth and yield of spring wheat and corn respectively under presowing treatment and have reported favourable effects. Malykhina (1960) also studied the effect of boric acid on the growth and yield of hybrid corn under presowing treatment and reported favourable effects.

Material and Methods

Present investigations were carried out on *Hordeum vulgare* L. var. C 251 in the Botanical gardens of the University of Allahabad. The micro-elements namely copper, zinc and manganese were used in the form of $CuSO_4$, $ZnSO_4$ and

$MnCl_2$ respectively. Preliminary experiments were performed to find out the concentrations at which the maximum germination took place. It was observed that maximum germination was in aqueous solution of 0 03% in Cu, 0·04% in Zn and 0·08% in Mn. Healthy seeds of barley of approximately uniform weight and size were taken and washed with distilled water. They were then soaked for twenty four hours, separately in solutions of 0·03% $CuSO_4$, 0·04%, $ZnSO_4$ and 0·08% $MnCl_2$ and also in a mixture of all the three elements of above concentrations mixed in equal proportion. Afterwards they were removed, thoroughly washed in running water and sown in unglazed clay pots of 26 cm. height which were coated with bitumen paint from inside and were filled with soil and cowdung manure in proportion of 5 : 1; the latter was thoroughly mixed to make it uniform. Similarly a control was also run in which untreated seeds were soaked in distilled water for twenty four hours and then sown in pots in the manner indicated above. Sufficient number of pots were taken for each treatment and four plants were allowed to grow in each pot. Four pots of each treatment and control were set apart for taking growth records and rest of the pots were used for collection of leaf material at various stages. Growth records were taken at three physiological stages namely vegetative, heading and milky grain stages which were approximately 50, 70 and 90 days from the date of sowing. At these stages fully developed and healthy green leaves of approximately the same age and expansion were collected at each sampling date and dried in oven at 80°C, powdered and used for determination of nitrogen by micro-Kjeldahl method (Paech and Tracey 1956), potassium by the Cobalti-nitrite method (Piper, 1944), and phosphorus by the micro-colorimetric method (Horwitz, 1955). Similarly leaves were collected and chlorophyll was estimated in fresh leaves by the colorimetric method (Horwitz, 1955). The linear growth, tiller number, leaf number, leaf area, and leaf dry weight were recorded at each stage. Leaf area was measured by the method of Lal (1905). Ear characters such as number of ears per plant, length of ear, weight of ears per plant, number of spikelets per ear, number of grains per ear and absolute weight of the grains were recorded. At the time of harvest final straw and grain yield per plant were recorded. The experiments were conducted in quadruplicate and the results were analysed statistically. Analysis of variance has been done by F-test and statistical significance at five and one per cent levels has been reported in each case.

Experimental Results

Linear growth of the barley plants (Table I) was maximum in Zn treated plants and minimum in control at all the three growth stages. In general, there was an increase in height with increase in age of the plants upto milky grain stage. Tiller production was seen to be significantly affected at all the three stages of growth (Table I). At the vegetative stage maximum tillering was observed in Cu treated plants, but at heading and milky grain stages maximum tillering was recorded in Zn treated plants. With increase in age there was a rise in tillering upto heading stage and then a decline due to drying of some tillers. Leaf number and leaf area (Table I) was maximum in Zn treated plants at all the three stages of growth record. At the milky grain stage both leaf number and leaf area decreased in all the treatments as compared to heading stage. Leaf dry matter accumulation (Table I) was maximum in Zn treated plants at all the three growth stages. In general, there was a increase in dry weight with increase in age.

The number of ears per plant (Table II) increased in all the treatments as compared to control and was maximum in Mn treatment. Tne weight of ears

per plant (Table II) showed significant increase in Cu, Mn and Zn treatments as compared to mixture treatment and control. Ear length also increased in Zn treatment but no significant result was observed. Control had the least number of spikelets per ear and Zn had maximum number of spikelets per ear. Cu, Zn and Mn treated plants had higher number of grains per ear as compared to control and mixture. Absolute weight of one thousand grains had also been found to be significantly affected by Zn treatment as compared to all other treatments (Table II). In Zn treatment the grain yield was significantly higher than control (Table III). The effect of Cu, Mn and Zn treatments on straw production was also significant and it was maximum in Zn treatment. The straw/grain ratio was maximum in Zn treatment and minimum in control.

TABLE I

The effect of Cu, Mn, Zn and their mixture on the growth characters of barley plant at different physiological stages in its life-cycle

Growth stages	Control	Cu	Mn	Zn	Mixture	S.E.	C.D. 5%	C.D. 1%
Vertical Growth (height in cm)								
Vegetative	39·72	47·55	45·46	49 25	41·55	1·34)	4·128	5 788
Heading	55·35	50·01	58·65	65·81	57·87	1·650	5·083	7·127
Milky grain	65·72	70·02	73·47	78·75	67·65	1·275	3·928	5·507
Tiller Number (per plant)								
Vegetative	5·56	8·42	6·85	8·14	5·05	0·250	0·770	1·079
Heading	6·67	8·64	8·08	9·55	6·97	0·320	0·986	1·382
Milky grain	5·52	6·01	7·07	8·55	5·95	0·325	1·001	1·304
Leaf Number (per plant)								
Vegetative	18·35	27·25	24·72	30·17	18·05	1·505	4·637	5·507
Heading	27·47	32·92	36·85	40·47	28·55	1·420	4·375	6·134
Milky grain	22·92	18·02	24·85	29·55	25·05	1·250	3·857	5·399
Foliage Expansion (Area in sq. cm./plant)								
Vegetative	25·03	30·15	32·16	35·67	26·64	0·800	2·464	3·455
Heading	28·65	33·68	34·85	40·55	31·97	0·750	2·310	3·239
Milky grain	24·35	33·55	30·55	36·52	23·05	0·980	2·742	3·844
Leaf Dry Matter (gm/plant)								
Vegetaive	0·653	0·684	0·662	0·782	0·692	0·083	0·255	0·358
Heading	0·875	0·958	0·943	0·989	0·887	0·095	0·292	0·410
Milky grain	1·064	1·225	1·232	1·288	1·035	0·112	0·345	0·483

At the vegetative stage a rise in leaf nitrogen as compared to control was noticed in Cu and Mn treatments, and the maximum value was found in Zn treated plants. At the heading stage the effect of Zn treatment on nitrogen uptake proved to be significant (Table IV). There was a rise in nitrogen in all the treatments as compared to control. Maximum nitrogen was recorded in Zn treatment. At the milky grain stage a fall in leaf nitrogen was observed in all treatments. Mn and Zn treatments again led to an increase in nitrogen uptake as compared to the rest of the treatments including control. The amount of P taken up by the plants at the vegetative stage was maximum in Zn treatment while Mn treatment had even lower values than those in the control (Table IV). At the heading stage P uptake showed a rise in Cu, Zn and mixture treatments as compared to control. A highly significant increase was seen in P uptake in Zn treatment at the milky grain stage. With increase in age of the plants up to the heading stage, increased percentage of P in the leaves of all the treatments was noted and thereafter a fall.

TABLE II

The effect of Cu, Mn, Zn, and their mixture on the ear characters of barley at the time of harvest

Characters	Control	Cu	Mn	Zn	Mixture	S.E.	C.D. 5%	C.D. 1%
Ear/plant (No.)	4·05	5·92	6·92	5·77	4·55	0·930	2·865	4·017
Ear weight (gm/ plant)	6·94	7·81	8·71	8·99	6·80	0·275	0·847	1·185
Ear length (cm)	15·12	15·47	15·80	16·20	15·20	2·145	6·608	9·109
Spikelet No. (per ear)	10·37	12·25	11·93	13·25	10·93	0·535	1·648	2·311
Grain No./ear	26·85	28·60	29·65	30·45	26·97	0·950	2·927	4·103
Grain wt. (absolute, gm)	39·27	40·97	39·75	44·50	40·11	1·005	3·096	4·341

TABLE III

Grain and straw yield of barley as affected by Cu, Mn, Zn and their mixture (gm./plant)

Yield	Control	Cu	Mn	Zn	Mixture	S.E.	C.D. 5%	C.D. 1%
Grain/plant	7·110	8·470	9·520	10·978	7·530	1·230	3·789	5·386
Straw/plant	6·474	7·604	7·849	8·127	6·724	0·285	0·878	1·231
Straw/grain ratio	0·037	0·047	0·042	0·049	0·044	0·029	0·091	0·127

The uptake of K was significantly affected by treatments at the heading and milky grain stages only. The uptake of K increased only in Zn and Cu treatments as compared to control at the heading stage. At the milky grain stage,

the highest value was recorded in Zn treated plants. Total leaf chlorophyll (Table IV) was maximum in Zn treatment and minimum in control at the vegetative and heading stages. At the milky grain stage Mn treatment showed maximum chlorophyll content whereas control showed minimum. In general, there was a rise in total leaf chlorophyll content upto 70 days and after this there was a decrease with increase in age.
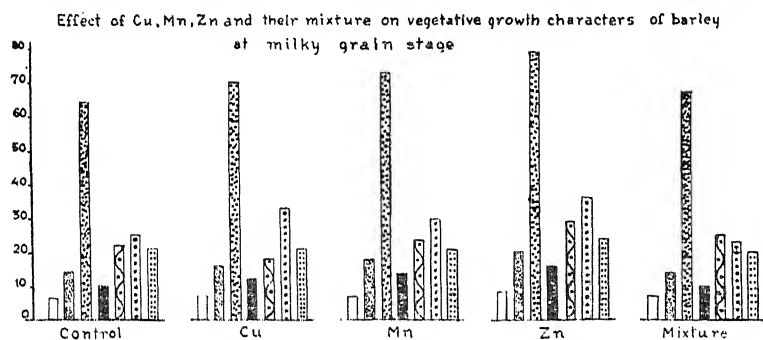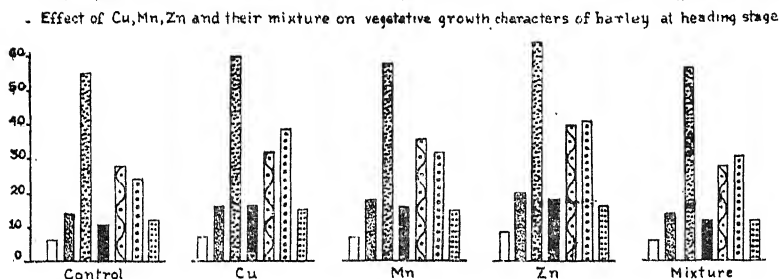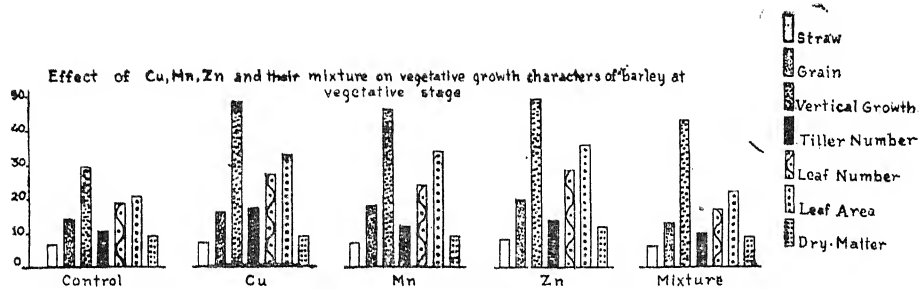
Discussion

Copper, zinc and manganese played a positive and significant role in influencing most of the plant characters studied. By critical examination of the growth characters at vegetative stage, it is seen that maximum vertical growth, leaf number, leaf area and leaf dry matter is seen in Zn treated plants as compared to the rest of the treatments including control. Increase in vertical growth and leaf number as a result of Zn application has also been reported by Reed (1939). Chandler (1937) observed that lack of Zn lowered the height of the plant as well as the number of leaves. This increase in vertical growth, leaf number, leaf area, leaf dry matter in Zn treated plants as compared to the rest of the treatments including control is due to the favourable affect of Zn on the auxin production as reported by Skoog (1940). The uptake of N and P in Zn treated plants has been found to be maximum and a corresponding increase in vertical growth, leaf number, and leaf dry matter has been observed in this treatment at the vegetative stage (Fig. 1).

TABLE IV

*Leaf composition at different physiological stages of growth of the barley plant*

Growth stages	Control	Cu	Mn	Zn	Mixture	S.E.	C.D. 5%	C.D. 1%
Nitrogen (N) mg. per 100 mg. (on oven dry weight basis)								
Vegetative	2·975	3 012	3·234	3·461	2·751	0·195	0·590	0·842
Heading	4·018	4·079	4·262	4·561	4·154	0·147	0·452	0·634
Milky grain	3·162	3·257	3·395	3·658	3·056	0·175	0·539	0·754
Phosphorus (P) mg. per 100 mg. (on oven dry weight basis)								
Vegetative	0·0038	0·0035	0·0025	0·0040	0·0028	0·0051	0·0015	0·0022
Heading	0·0048	0·0054	0·0043	0·0057	0·0046	0·0012	0 0026	0·0051
Milky grain	0·0040	0·0050	0 0038	0·0054	0·0042	0·0001	0·0003	0 0004
Potassium (K) mg. 100 mg. (on oven dry weight basis)								
Vegetative	3·921	4·384	3·756	4·283	3·872	0·127	0·391	0·548
Heading	4·345	4·586	3·483	4·967	3·662	0·165	0·508	0·712
Milky grain	3·164	3·471	2·395	3·784	2·874	0·185	0·570	0·799
Total leaf chlorophyll μg/100 mg. (on fresh weight basis)								
Vegetative	70·50	75·54	73·40	77·82	72·51	2·735	8·426	9·094
Heading	79·25	84·40	83·20	87·50	81·32	2·532	7·807	10·946
Milky grain	63·20	65·53	70·53	67·50	64·40	2·934	9·039	12·674

Effect of Cu,Mn,Zn and their mixture on vegetative growth characters of barley at vegetative stage

Effect of Cu,Mn,Zn and their mixture on vegetative growth characters of barley at heading stage

Effect of Cu,Mn,Zn and their mixture on vegetative growth characters of barley at milky grain stage

Note : Final grain and straw yield per plant have been shown at all the stages for ready reference and easy comparison

FIG. II

Effect of Cu,Mn,Zn and their mixture treatments on the leaf N, P, K and total chlorophyll at different physiological stages
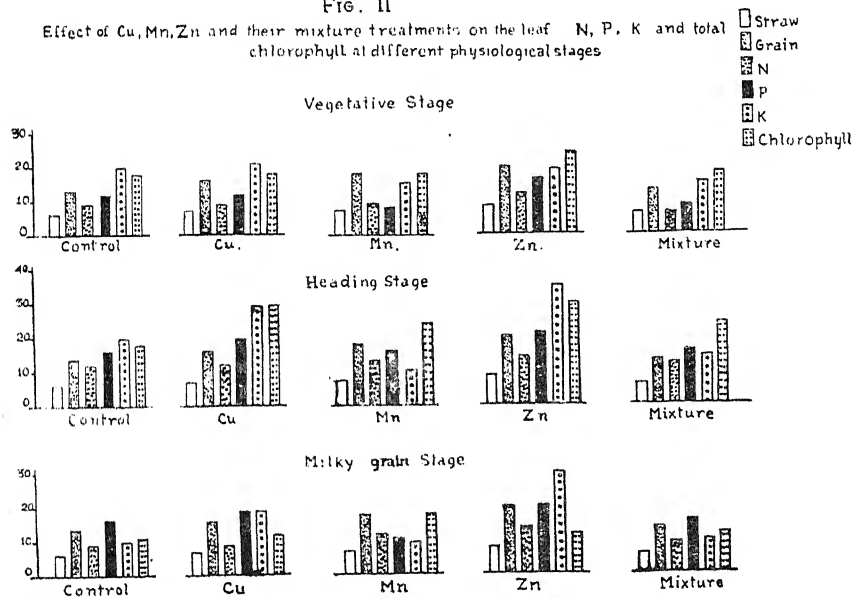
Vegetative Stage

Heading Stage

Milky grain Stage

Note :- Final grain and straw yield per plant have been shown at all the stages for ready reference and easy comparison.

The tiller number in Cu treated plants at the vegetative stage is maximum and there is also an increased uptake of K at this stage in this treatment as compared to the rest of the treatments. It is due to the favourable affect of Cu on the uptake of K (Fig. II). It shows that the treatment of barley seeds at the time of sowing with Cu has led to an increased uptake of K as revealed by leaf analysis (Table IV), which in turn has favourably influenced the growth especially tillering. Similar observations have also been reported by Stout and Arnon (1939). The uptake of P and K in the Mn treated plants was minimum as compared to all other treatments including control at the vegetative stage but there has been an increase in the N uptake in this treatment, which has favourably affected the vegetative growth (Fig. I). There has been slight increase in the growth characters of mixture treated plants over that of control but there has been no corresponding increase in uptake of K and P which has been even less than that of control (Fig. II). This decreased uptake of P and K is due to the presence of Mn which when given separately has also adversely affected the uptake of these elements (Table IV).

At the heading stage, there has been maximum growth in all the vegetative characters recorded in Zn treatment. Increase in vertical growth and leaf number as a result of Zn application are quite in accordance with the findings of Camp (1945) and Davis (1958) who noted that Zn increased the number of leaves in different plants. Leaf area also showed very marked rise in Zn treated plants as compared to all other treatments including control. Similar effect of Zn on leaf area has also been observed by Howard Dale (1960). Thus, it is seen that Zn favoured leaf expansion because in Zn treatment more of N uptake was seen which had a favourable effect on leaf area (Fig II). The dry matter accumulation was found to be maximum in Zn treated plants as compared to all other treatments including control. Sommer (1928) and Virtanen (1953) reported that the application of Zn maintained a more balanced growth of the plants.

The final grain and straw yield has also been found to be maximum in Zn treated plants (Table III). Reed (1942) has also reported higher yield in different crops by the use of Zn. The influence of presowing treatments on yield was most pronounced in Zn treated plants. The increased grain and straw yield in Zn treated plants has been due to the Zn treatment which has enhanced the growth of the barley plants. The higher yield of the plants treated with Zn could be correlated with the high uptake of N and K observed in such plants and also the increased tillering. Straw yield also increased with Zn, Cu, Mn and their mixture treatments as compared to control (Table III) and maximum straw yield was recorded in Zn treated plants. Similar increase in straw yield was also reported by Reed (1942). Straw/grain ratio showed a gradual increase from control in all treatments and maximum straw/grain ratio was observed in Zn treated plants. There has also been a maximum uptake of N and K and also leaf chlorophyll as compared to rest of the treatments including control.

Percentage of N, P and K in the barley leaves was found to increase between 50–70 days and then a decrease was noted. Schertz (1929) also showed that with the growth of reproductive structures the nitrogenous compounds are translocated from leaves and stems to the developing seeds and this movement results in the lowering of the concentration of N in the leaves. The high value of N at all the stages in Zn as compared to control further supported the view that Zn favoured N uptake. In barley leaf P was found to increase between 50–70 days i.e., at the time of flowering. But later on it tended to decrease with age in all the treatments. The decrease of P in the leaves may also be due to its

translocation to reproductive parts, where it is usually believed to be transferred. The uptake of K was very rapid in Zn treatment between 50–70 days as shown by leaf analysis (Table IV). A corresponding increase in the growth of the plants was seen (Fig. I). These data clearly indicate that higher uptake of N, P and K and also chlorophyll content in leaf at the heading stage is associated with the increased final yield.

In Cu treated plants at the heading stage there has been an increased uptake of N, P and K as compared to control (Fig. II). There has also been a corresponding increase in vegetative growth characters which indicates that Cu treatment has favourably affected the growth and uptake as against control. Similar effect of Cu given in soil on vegetative growth characters has also been observed by Sommer (1931). Thus it indicates that the treatment of barley seeds at the time of sowing with Cu has led to an increased uptake of K as revealed by leaf analysis (Table IV) which in turn has favourably influenced the growth especially tillering. Similar observation has also been reported by Mitchell (1944).

The uptake of P in the Mn treated plants at the heading stage was minimum as compared to all other treatments at this stage and this condition was true even at the milky grain stage (Fig. II). This decreased P and K uptake has delayed the maturity of the plants in this treatment. This fact is supported by the amount of total chlorophyll which is maximnm in Mn treatment at the milky grain stage (Table IV). The fact that the active growth has continued is further supported by the uptake of N which has remained comparatively high at the heading and the milky grain stages as compared to all other treatments except Zn treatment (Fig. II). The number of ears per plant at the time of harvest was maximum in Mn treated plants. Therefore, it seems that ear bearing tillers continued to be produced in this treatment ; whereas in Zn treatment which although recorded maximum number of tillers at the milky grain stage could not produce maximum number of ear bearing tillers. Increase in ear number as a result of Mn application is quite in accordance with the findings of McHargue (1923).

The uptake of P and K in mixture and Mn treated plants is less than that in control at the heading stage. In these treatments the leaf K values decreased with increase in age of the plants which continued upto milky grain stage, whereas in control, Cu and Zn treatments there had been an increase in K uptake at heading stage as compared to the vegetative stage, and then a subsequent fall with increase in age as seen at the milky grain stage (Fig. II). This fact indicates that there has been some detrimental effect of the presence of Mn on the uptake of K from the very beginning. This detrimental effect has been less pronounced in tne Cu-Mn-Zn mixture treated plants probably due to the presence of Cu and Zn which when given separately have definitely led to an increase in the uptake of P and K. Similar observations have been reported by Sideris and Young (1949) that manganese also affects magnesium content of tissues though calcium, potassium and phosphorus are not much affected.

Summary and Conclusion

A study on the effects of Cu, Mn and Zn and their mixture treatments to the seeds of barley (*Hordeum vulgare* L. var. C. 251) grown in pots in sandy loam soil was conducted. $CuSO_4$ (0·03%), $Mncl_2$ (0·08%), $ZnSO_4$ (0·04%) and their mixture at the above concentrations were given to the seeds at the time of sowing. Along with these a control was also run consisting of untreated seeds. Observations were taken at the vegetative, heading and milky grain stages which

were at 50, 70 and 90 days from the date of sholwing. Height, tiller number, leaf number, leaf area and leaf dry weight were recorded. Various ear characters and final grain and straw yield were also recorded at the time of harvest. Leaves were collected at all the three stages and were analysed for N, P, K and total leaf chlorophyll. All the results were subjected to statistical analysis and highly significant results have been obtained which have been discussed in detail.

The above study clearly indicates that presowing treatment with microelements has significantly affected the growth, yield and leaf composition of the barley. The vertical growth, leaf number, leaf area, tiller number and leaf dry matter were found to be higher in Cu, Mn and Zn treated plants as compared to control. All the growth characters studied were affected to a maximum extent in those plants which were given presowing treatment with Zn. The ear characters and final grain and straw yield were also found to be higher in those plants which were treated with Cu, Mn and Zn at the time of sowing as compared to those plants which were not given any presowing treatment. However, the presowing treatment of barley seeds with Zn gave the best and significantly highest results.

The uptake of N, P and K as revealed by leaf analysis at various physiological stages was also significantly affected by the presowing treatments. With comparison to control the uptake of P and K were recorded to be highest in those plants that were given presowing treatment with Cu and Zn. The presowing trentment with Zn led to an increase in the amount of total leaf chlorophyll at the vegetative and heading stages which in turn favourably affected the final yield. There is a positive correlation between the leaf-composition at the vegetative and heading stages and the final yield. Higher N, P and K uptake as revealed by leaf analysis are correlated with high final yield. This fact is best born out in Zn treated plants. Mn treatment delayed maturity of the plants which is evident from the amount of total leaf chlorophyll which was found to be maximum in this treatment at the milky grain stage. There has been a decreased uptake in Mn treated plants as revealed by the decreased amount of P and K recorded in the leaf at all the stages as compared to the rest of the treatments. Such presowing treatments with micro-elements can be of great practical utility and can be used to overcome the deficiency of the micro-elements present in different soils.

Acknowledgment

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CONTRIBUTION TO THE BOTANY OF MADHYA PRADESH—III
(The families *Ebenaceae* to *Convolvulaceae*)

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Introduction

Madhya Pradesh is one of the largest states of the Indian Union in the centre of India and, therefore, presents floristically one of the most interesting sectors of the country. Yet, no ·"Flora" exists for this State. With a view to overcome the lacuna in our knowledge of the botany of this area, some check-lists on trees, shrubs and herbs of parts of Madhya Pradesh (*c.f.* Wood, 1902 ; Hole, 1904 ; Witt, 1908, 1911, 1916 ; Biscoe, 1910 ; Haines 1916 ; Kenoyer, 1924 ; Sagreiya, 1938 ; Mooney, 1942 ; Narayanswamy, 1960 ; Maheshwari 1960, 1961, 1962, 1963 ; Subramanyam, 1961 ; Joseph, 1963) and papers dealing with the families, Gramineae, Cyperaceae and Orchidaceae (Tiwari, 1954, 1955, 1963 ; Tiwari and Maheshwari 1963, 1964) have been published.

As a result of several extensive collection tours undertaken between 1962 to 1964, about 3000 field numbers of plants have been collected. These have been identified to about 700 species. In two earlier communications in this series of papers (*c.f.* Panigrahi *et al*, 1965 and Panigrahi and Arora 1965) families Dillenia ceae to Rubiaceae (excluding the family Leguminosae) and comprising 193-species have been dealt with. This paper presents an enumeration of 74 species belonging to the families Ebenaceae to Convolvulaceae, following Bentham and Hooker's (1883) System. Our observations on the habit, habitat, colour of flowers and fruits, abundance, exact localities of their occurrence, names of collectors and the field nos. of plants and finally, the flowering and fruiting seasons, are appended to every species enumerated. The most recent names, consistent with the International Code of Botanical Nomenclature, have been utilised as far as available. The names used in the Flora of British India have been indicated by the abbreviation FBI, followed by volume and page reference against every species enumerated.

ENUMERATION

EBENACEAE

Diospyros cordifolia Roxb. ; FBI, 3 : 555.

Shrub upto 5 m. high, on hill slopes. Fruit globose, orange yellow in colour ; calyx persistent, large, foliaceous. Abundant. Katni : Sarda hills (Mahihar). *Panigrahi* 6696. Fruits December.

D. melanoxylon Roxb. ; FBI, 3 : 564.

Tree upto 10 m. high in mixed and sal forests ; bark greenish black, breaking into rectangular blocks. Calyx persistent, lobes cordate with wavy margins. Fruits globose, green-black with crustaceous pericarp. Abundant. Sidni : Majha-uli. *Panigrahi* and *Verma* 5641. Morena : Kunnoo. *Panigrahi*. 5915. Hoshangabad :

Dhupgarh. *Panigrahi* 6688. Sidhi. *Panigrahi* and *Singh* 2194. Fruits September to January.

D. peregrina Gurke ; *D. embryopteris* Pers. ; FBI, 3 : 556.

Evergreen tree growing in valleys along streams ; bark blackish. Fruits solitary, axillary, on short peduncles, brown velvety ; calyx persistent, lobes 4, large, auriculate. Abundant. Bastar : Chitrakut falls. *Panigrahi* and *Arora* 1187. Bilaspur : Dharamjaygarh. *Arora* 3786. Fruits February to April.

STYRACEAE

Symplocos spicata Roxb. ; FBI, 3 : 573.

Tree upto 8 m. high, in evergreen forests. Flowers sessile in branched axillary spikes. Drupe ribbed. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 6910, 6916. Jagdalpur : Mallinger valley. *Panigrahi* and *Arora* 1029. Flowers and fruits February.

OLEACEAE

Jasminum malabaricum Wt. ; FBI, 3 : 594.

Scandent shrub. Flowers white, pleasant smelling ; calyx lobes linear, hairy. Jagdalpur : Dhanora–Orchha. *Jain* 4060. Flowers April.

J. multiflorum (Burm.) Andr. ; *J. pubescens* Willd. ; FBI, 3 : 592.

A climbing shrub along roadside and in mixed forests. Flowers white, fragrant ; calyx teeth, densely villous. Abundant. Katni. *Panigrahi* 6692. Sidhi : Majhauli. *Panigrahi* and *Singh* 2360. Bilaspur : Jashpurnagar. *Arora* 3876. Flowers and fruits December to May.

Nyctanthes arbor-tristis Linn. ; FBI, 3 ; 603.

Shrub upto 5 m. in the outskirts of dry deciduous forests and on hill tops. Flowers creamy white, scented, corolla tube pink. Capsule green to brown, compressed. Abundant. Rewa : Suhagighat. *Panigrahi* 5005. Sidhi. *Panigrahi* and *Verma* 5417. Sidhi : Majhauli. *Panigrahi* and *Singh* 2127. Jagdalpur : Motinala. *Jain* 2809. Flowers and fruits September to January.

Schrebera swietenioides Roxb. ; FBI, 3 : 604.

Tree upto 10 m., in mixed deciduous forests. Capsule woody, obovoid, greenish brown, 2–valved, drooping downwards; highly whitish lenticular on green body. Morena : Goras. *Panigrahi* 5913. Jagdalpur : Chandanor forests *Panigrahi* and *Arora* 6828. Fruits November to February.

APOCYNACEAE

Carissa congesta Wight ; *C. carandas* Linn. ; FBI, 3 : 630.

Thorny shrub upto 3 m. on forest edges and rocky slopes ; spines straight or slightly curved. Berries brownish green turning black on ripening, sour in taste. Abundant. Sidhi : Dubri. *Panigrahi* and *Verma* 5621. Sidhi : Barkadol. *Panigrahi* and *Singh* 2172. Fruits October to January.

Catharanthus pusillus G. Don. ; *Vinca pusilla* Murr. FBI, 3 : 640.

Annual herb along cultivated fields and on banks of rivers. Flowers minute, greenish, ; sepals filiform. Follicles in pairs, dehiscent. Raipur. *Jain* 5265. Hoshangabad : Bori. *Panigrahi* 6288. Flowers and fruits October to December.

Holarrhena antidysenterica Wall. ; FBI, 3 : 644.

Shrub upto 5 m. high, in open *Anogeissus pendula—Acacia catechu* forests. Flowers white. Follicles in pairs, cylindrical with small white spots. Abundant. Jagdalpur : Dantewara. *Jain* 5187. Jagdalpur : Sukma. *Jain* 5233. Gwalior : Kunnoo river bank. *Panigrahi* 5899. Fruits September to November.

Wrightia tinctoria R. Br. ; FBI, 3 : 653.

Tree upto 5 m., in dry and moist deciduous forests, amongst rocks ; with milky latex. Follicles in pairs upto 30 cm. long, dark green, lenticular, joined at tip when young. Abundant. Gwalior : Takanpur. *Arora* 62. Rewa : Suhagi hills. *Panigrahi* and *Verma* 5430, 5431. Gwalior : Pabra damsite. *Panigrahi* 5811. Hoshangabad : Pachmarhi. *Panigrahi* 6594. Rewa : Chachai fall. *Panigrahi* and *Singh* 2472. Fruits October to January.

W. tomentosa R. & S. ; FBI, 3 : 653.

Shrub upto 5 m. high. Follicles connate into a cylindric body with deep groove on each side, tapering at both ends, rough with white tubercles. Fairly abundant. Hoshangabad : Dhupgarh. *Panigrahi* 6677. Fruits December.

Nerium indicum Mill ; *N. odorum* Soland ; FBI, 3 : 655.

Shrub upto 5 m., along streams. Fruits in pairs, green and ribbed when young, on maturity becoming brown, dehiscent ; seeds with brownish silky coma Scarce. Shivpuri : *Panigrahi* 6079. Fruits November.

Ichnocarpus frutescens R. Br. ; FBI, 3 : 669.

Shrubby climber, upto 10 m. high, forming canopy on trees and shrubs. Flowers white-pinkish, scented, in rusty, pubescent cymes ; corolla-lobes deflected, villous. Fruit a pair of slender follicular mericarps. Abundant. Katni ; Lakhapateri. *Panigrahi* 5050. Balaghat-Seoni. *Jain* 5274. Rewa : Kaimur hills. *Panigrahi* and *Verma* 5535 Rewa. *Panigrahi* and *Arora* 6165. Sidhi : *Panigrahi* and *Singh* 2143. Flowers September to November. Fruits January to February,

ASCLEPIADACEAE

Hemidesmus indicus (Linn.) Schult. ; FBI, 4 : 4

Shrubby climber upto 7 m. Leaves very variable in form. Flowers yellowish brown, corolla rotate, lobes fleshy. Fruits in pairs. Abundant. Raipur : Kanker-Keskal. *Jain* 5127. Hoshangabad : Kesla. *Panigrahi* 6411. Flowers September ; Fruits December.

Cryptolepis buchanani Roem. and Schult. ; FBI, 4 : 5

Climber on *Tectona grandis*, and shrubs. Follicles usually paired, broader in the middle and tapering towards ends. Fairly abundant. Hoshangabad : Ludhidhana. *Panigrahi* 6271. Fruits December.

Calotropis gigantea R. Br. ; FBI, 4 : 17.

Shrub with milky latex in sandy bed of river and in dry exposed habitats. Flowers bluish-white, corolla lobes recurved and spreading. Abundant. Bilaspur : Dharamjaygarh. *Arora* 3814. Flowers April.

C. procera R. Br. ; FBI, 4 : 18.

Shrub with milky latex, scattered in fields and valleys in dry deciduous forests, Flowers whitish-pink, corolla lobes erect. Abundant. Betul : Chicholi. *Panigrahi* 6396. Flowers December.

Pentatropis spiralis DCne. ; FBI, 4 : 19..

Twinner, occurring on hill top (1300 m.). Flowers axillary, corolla-lobes elongate, caudate. Follicles broad near the tapering base, gradually narrowed to a pointed tip. Scarce. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 6988. Flowers and Fruits February.

Gymnema sylvestre R. Br. ; FBI, 4 : 29.

Climber upto 6 m. on bushes forming netted appearance. Follicles in pairs, green, tapering at both ends. Abundant. Rewa : Suhagighat. *Panigrahi* 6148. Hoshangabad : Kesla. *Panigrahi* 6441. Jagdalpur : Chitrakuta falls. *Panigrahi* and *Arora* 1192. Fruits November to February. Hindi Gudmar.

Pergularia daemia (Forsk.) Chiov. ; *Daemia extensa* R. Br. ; FBI, 4 : 20

Climber upto 7 m. ; stem brown pubescent with emergences. Flowers reddish brown outside and pale yellow inside. Follicles upto 5 cm., spindle-shaped, green to greenish violet, covered with short echinate outgrowths. Abundant. Rewa : Govindgarh Road. *Arora* 1397. Sidhi : Dubri. *Panigrahi* and *Verma* 5635. Shivpuri. *Panigrahi* 6075. Bhopal. *Panigrahi* 6241. Sidhi : Garhwa *Panigrahi* and *Singh* 2451. Nagpur-Raipur. *Panigrahi* and *Arora* 6735. Flowers and fruits October to February.

Dregea volubilis Benth. var. **lacuna** Hk.f. ; FBI, 4 : 47.

Climber upto 10 m. in dry deciduous thorn forests. Follicles in pairs, about 9 cm. long and 1·5 cm. broad, tapering at ends, full of latex. Abundant. Morena : Kunnoo. *Panigrahi* 5862. Fruits November.

LOGANIACEAE

Buddleia asiatica Lour. ; FBI, 4 : 82.

Shrub upto 2 m. high ; along riverbank and streams. Flowers white, scented. Capsule brown, drooping, dehising by valves. Fairly abundant. Rewa : Nand forests. *Arora* 672. Hoshangabad : Rorighat. *Panigrahi* 6526. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 1067. Sidhi : Jiyawan. *Panigrahi* and *Singh* 2402. Flowers and fruits December to February.

GENTIANACEAE

Exacum perrottetii Griseb. ; FBI, 4 : 95.

Herb upto 0·5 m., stem rectangular having two sides, grooved alternately from nodes. Flowers tetramerous, blue violet. Capsule globose-ovoid. Scarce. Jagdalpur : *Panigrahi* and *Arora* 6842. Flowers and fruits February.

Exacum pedunculatum Linn. ; FBI, 4 : 97.

Annual herb upto 25 cm. high ; in muddy habitat ; stem winged. Flowers violet. Scarce. Mahihar : Lalpur. *Panigrahi* 6221. Flowers December.

Hoppea dichotoma Willd. FBI, 4 : 100.

Annual succulent pale green herb upto 12 cm., in roadside drains in black alluvium and in sandy loam. Flowers pale yellow. Capsules globose, covered with acute calyx teeth. Abundant. Gwalior : Dabra. *Panigrahi* 5762. Sidhi : Majhauli. *Panigrahi* and *Singh* 2118. Flowers and fruits November to January.

Erythraea roxburghii G. Don. ; FBI, 4 : 102.

Annual herb upto 25 cm., in dried up drains under shade, along roadsidet. Flowers pink with whitish throat, papery when dry, funnel–shaped. Abundan· Deolapara-Nagpur. *Panigrahi* and *Arora* 6719. Flowers February.

Canscora diffusa R. Br. ; FBI, 4 : 103.

Annual dichotomously branched herb upto 25 cm., in black alluvium and amidst pebbles and lateritic soil ; along water in shade. Stem 4-angled. Flowers pink. Abundant. Rewa. *Arora* 658. Shivpuri. *Panigrahi* 6090 Satna : Khajuraho. *Panigrahi* 6138. Hoshangabad : Bori. *Panigrahi* 6265. Sidhi : Majhauli. *Panigrahi* and *Singh* 2103. Bilaspur : Partabpur. *Arora* 3941. Flowers November to May.

Canscora decussata Roem. and Sch. ; FBI, 4 : 104.

Slender annual herb upto 30 cm. ; stem 4-angled, stem and pedicels winged, the wings broader above. Flowers white. Capsule brownish white, spindle shaped. Sidhi : Gandhigram. *Panigrahi* and *Verma* 5594. Sidhi : Barda–Chittarangi. *Panigrahi* and *Singh* 2413. Flowers and fruits October to January.

Swertia corymbosa Wt. ; FBI, 4 : 126.

Herb upto 1 m. high. Dry petals white papery. Capsule about 1 cm. long with numerous dark brown rugose seeds. Abundant. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 6851. Flowers and fruits February.

Nymphoides cristatum (Roxb.) O. Kuntze ; *Limnanthemum cristatum* Griseb. ; FBI, 4 : 131.

Perennial aquatic plant in shallow water and mud. Stem petiole-like endin into an orbicular cordate leaf. Corolla white ; petals entire with a ridge-like protuberance in the middle. Abundant. Raipur. *Panigrahi* 5099. Morena : Kunnoo. *Panigrahi* 5864. Rewa : Mohri Katra. *Panigrahi* 6201. Sidhi : Majhauli *Panigrahi* and *Singh* 2197. Flowers September to April.

Nymphoides indicum (L.) O. Kuntze ; *Limnanthemum indicum* (Linn.) Griseb. emed Thw. ; FBI, 4 : 131.

Perennial aquatic plant floating in ponds. Leaves at the end of petiole like stem, orbicular, cordate, much larger than *N. cristatum* and are upto 22 cm. in dia. Flowers snow white ; petals fimbriated. Abundant. Rewa : Roopsagar Lake *Arora* 682. Hoshangabad : Bori. *Panigrahi* 6380. Flowers December to February.

HYDROPHYLLACEAE

Hydrolea zeylanica (L.) Vahl. ; FBI, 4 : 133.

Annual creeping herb rooting at nodes with ascending branches upto 9 cm ; in loamy soil under shade. Flowers pinkish white to blue violet. Capsule thin and transparent. Morena : Goras. *Panigrahi* 5941. Jagdalpur : Dantewara. *Pnnigrahi* 6779. Flowers and fruits November to February.

Cordia macleodii HK. f. & Th.

Tree upon 6 m., bark peeling off in blocks, bark white inside ; flowers creamy yellow, fruits small enclosed in woolly calyx. Bilaspur : Jashpurnagar, *Arora* 3831. Flowering April.

Cordia grandis Roxb. ; FBI, 4 : 137.

Tree upto 14 m. high in evergreen .forests. Fruits pale green purple. Scarce. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 6955. Fruits February.

Coldenia procumbens Linn. ; FBI, 4 : 144.

Perennial rosette-like, white silky herb in recent sandy alluvium along streams ; one of the pioneer species in such areas. Flowers yellowish, inconspicuous. Drupes brown. Gwalior : Pabra damsite. *Panigrahi* 5826. Rewa : Rani Talab *Hanfi* 1484.

Rotula aquatica Lour. ; *Rhabdia lycioides* Mart. ; FBI, 14 : 145.

Undershrub upto 1 m. along the sandy banks and in the sandy and rocky bed of the rivers ; stem brown, leathery hard. Flowers blood red-pink. Drupe red, of 4 pyrenes. Abundant. Jagdalpur : Mukki. *Jain* 5281. Jabalpur : Chhapra *Panigrahi* 6231. Jagdalpur : Dantewara : *Panigrahi* and *Arora* 6766. Rewa, Chachai *Panigrahi* 2467. Flowers and fruits December to February.

Heliotropium supinum Linn. ; FBI, 4 : 149.

Annual whitish woolly herb along roadside. Flowers white ; Calyx densely hairy enclosing the fruit ; corolla lobes rounded. Nutlets 2, rugose. Saugar : Seoni. *Panigrahi* 6249. Flowers and fruits December.

H. ovalifolium Forsk. ; FBI, 4 : 150.

Annual herb branching from a perennial rootstock ; in dried up ditches and along water ; the plants hairy to densely white woolly. Flowers white ; sepals not enclosing the fruit. Nutlets 4. Abundant. Gwalior : Pabra damsite. *Panigrahi* 5816, 5827. Rewa : Amarpatan. *Panigrahi* and *Arora* 6707. Indore ; Mhow, *Arora* 5567. Flowers and fruits September.

H. strigosum Willd. FBI, 4 : 151.

Diffuse herb to sandy riverbed and alongside ; whole plant white strigose. Flowers white ; calyx not completely covering the fruits. Fruits 4-lobed Fairly abundant. Bilaspur ; Dharamjaygarh. *Arora* 3777, 3793. Flowers April.

H. scabrum Retz. ; FBI, 4 : 152.

Annual diffuse hairy plant, branches spreading from a woody rootstock. Flowers white. Fruits 4-lobed. Fairly abundant. Raipur. *Panigrahi* 5094. Morena : Goras. *Panigrahi* 5931. Flowers and fruits September to November.

H. indicum Linn. ; FBI, 4 : 152.

Annual herb covered with stiff hairs. Flowers purple. Fruits ovoid, ribbed seperating into two pyrens. Abundant. Jagdalpur : Dantewara. *Jain* 5161 Flowers and fruits September.

Trichodesma indicum R. Br. ; FBI, 4 : 153.

Annual stiff hairy xerophytic herb upto 0·5 m., on hill slopes and amidst grasses. Flowers blue violet to pink, sometimes even white. Fruits of 4 nutlets which are rugosely regularly pitted. Hoshangabad : Rorighat. *Panigrahi* 6528. Bilaspur : Jashpurnagar, *Arora* 3835. Flowers and fruits December.

T. amplexicaule Roth ; FBI, 4 : 153.

Annual hirsute herb upto 50 cm. hairs stiff hairy. Flowers bluish ; petals with slight pinkish tinge ; connectives dark chocolate with whitish woolly outgrowths. Fruits of 4 nutlets enclosed by calyx. Abundant, Rewa : Chachai falls. *Hanfi* 3311. Rewa. *Panigrahi* and *Verma* 5504. Raipur, *Panigrahi* and *Arora* 6741, Indore, *Arora* 5511. Hoshangabad : Adna river, *Panigrahi* 4338. Flowers and fruits October to February.

T. zeylanicum R. Br. ; FBI, 4 : 154.

Annual hairy weed in cultivated fields. Flowers bluish ; calyx lobes at fruiting stage rounded at base, never hastate, Fruits of 4 nutlets. Fairly abundant. Jagdalpur : Montinala–Rul. *Jain* 2924. Hoshangabad : Bori–Betul. *Panigrahi* 6410. Flowers and fruits December to January.

Cynoglossum zeylanicum (Wall.) Thunb. ex Lehms. *C. furcatum* Wall. ; FBI, 4 : 155.

Perennial herb upto 1·25 m., in forest undergrowth and in frost hole of Harapara (Bori) ; stem and leaves apressed hairy ; flowers bluish white. Nutlets dull green to dirty grey, covered with prickles which stick to clothings. Abundant. Hoshangabad : Bori. *Panigrahi* 6451. Dhupgarh. *Panigrahi* 6654. Jagdalpur : Mallingar valley. *Panigrahi* and *Arora* 1025. Flowers and fruits December to February.

C. wallichii G. Don. ; FBI, 4 : 157 *C. glochidiatum* Wall. ; FBI, 4 : 156. *C. denticulatum* DC. ; FBI, 4 : 151.

Perennial herb ; stem covered with bulbous based hairs. Nutlets covered with glochidia. Abundant. Jagdalpur : Kanker-Keskal. *Jain* 5123. Fruits September.

CONVOLVULACEAE

Rivea hypocrateriformis Choisy ; FBI, 4 : 184.

Climber on *Zizyphus* sp. along with *Cardiospermum helicacabum* in dry decidutous forests. Flowers pink, fruits brown. Common. Morena : Kannoo river back. *Panigrahi* 5900. Betul : Kothalkunda, *Panigrahi* 4324. Flowers July. Fruirts November.

Argyreia nervosa (Burm. f.) Boj = *A speciosa* Sw. FBI, 4 : 185.

Climber upto 10 m. high ; leaves whitish on the under surface. Fruits dry, shining brown with persistent calyx ; bracts deciduous. Jagdalpur : Kanger valley : *Panigrahi* and *Arora* 1127. Fairly abundant. Fruits February.

A. daltoni Clarke. ; FBI, 4 : 190.

Climber, sometime creeping amdish forest undergrowth ; flowers purple. Raipur : Jagdalpur 100 mile. *Jain* 5115 : Flowers September.

A. setosa (Roxb.) Choisy ; *Lettsomia setosa* Roxb ; FBI, 4 : 194.

A climber on hedges. Flowers pink. Scarce. Jagdalpur : Narayanpur-Daudai road. *Jain* 4006. Flowers November.

A. involucrata C. B. Clarke. ; FBI, 4 : 187.

Climber upto 3 m. ; in a nala ; fruits on long pedunculate cymes, face brown, leaving the calyx spread out after it has fallen. Scarce. Jagdalpur : Dantewara-Chandenar forests. *Panigrahi* and *Arora* 6820. Fruits February.

A bella (Clke.) Raizada. *L. bella* Clke.

Climber ; young parts densely tomentose ; fruits dehiscent. Bilaspur : Jashpurnagar, *Arora* 3851.

Erycibe paniculata Roxb.

Climbing shrub. young parts tomentose ; flowers yellow ; fruits black, fleshy. Bilaspur : Kathgora, *Arora* 3718. Flowering and fruiting April.

Ipomoea muricata (Linn.) Jacq. ; FBI, 4 : 197.

Climber upto 3 m. ; stem brown, covered sometime with minute recurved prickles. Flowers with chocolate white sepals. Seeds dark brown, glabrous. Abundant. Jagdalpur. *Jain* 5204 ; Sidhi. *Panigrahi* and *Verma* 5020. Flowers and fruit September to October.

I. angulata Lamk. ; *I. coccinea* Linn. ; FBI, 4 : 199.

Scandant herb, often climbing on roadside bushes forming tangled mass, stem brownish. Flowers blood red. Capsule smooth ovoid. Cultivated in gardens, often found as an escape. Sidhi : Dubri. *Panigrahi* and *Verma* 5618 ; Nigod. *Panigrahi* 6143 ; Hoshangabad : Bori. *Panigrahi* 6342. Flowers and fruits October to December.

I. quamoclit Linn. ; FBI, 4 : 199.

Spreading climber on shurb. Flowers with corolla tube light red but lobes shining red ; cultivated, sometime as escape. Jagdalpur : Gidam. *Jain* 5173 ; Sadhi : Majhauli. *Panigrahi* and *Verma* 5608. Flowers September to October.

I. pestigrides Linn. ; FBI, 4 : 204.

A profusely hairy climber upto 2 m. Fruits pale white turning brown on maturity ; seeds black. Abundant. Jagdalpur : Sukma. *Jain* 5239. Rewa. *Panigrahi* and *Verma* 5503. Gwalior : Pabra dam site. *Panigrahi* 5805. Flowers and fruits September to November.

I. obscura Ker-Gawl. ; FBI, 4 : 207.

Climber on bushes and hedges upto 3 m. Flowers pale yellow, pink at base only. Fruits shining from a distance ; seeds dark brown. densely hairy. Abundant. Morena : Sabalgarh. *Panigrahi* 5855. Shivpuri-Jhansi Road. *Panigrahi* 6105 Flowers and fruits November.

I. aquatica Forsk. *I. reptans* Poir. ; FBI, 4 : 210.

Creeper in mud and in shallow water, sometime climbing in a nala. Flowers pinkish white ; corolla darker in the throat. Abundant. Rewa : Kakshmi Talab. *Hanfi* 1461. Morena : Kunnoo. *Panigrahi* 5852. Jagdalpur : Bailadilla. *Panigrahi* and *Arora* 6893. Flowers and fruits February to April.

I. pilosa Sweet ; FBI, 4 : 213.

Climber on hedges, next to swampy near dam. Flowers dark brown. Scarce, Gwalior : Jora. *Panigrahi* 5806. Flowers November.

I. crassicaulis (Benth.) B. L. Robinson.

A commonly cultivated shurb for hedges upto 2 m. high, sometime an escape ; stem hollow. Flowers pinkish outside but red inside. Balaghat. *Jain* 5267. Sidhi : Deosar, *Panigrahi* and *Verma* 5426. Bilaspur : Kathgora. *Arora* 3742. Flowers October to April.

I. cymosa R. & S.

Climber on bushes by the side of a nala ; fruits brown. Bilaspur : Dharmanjoygarh, *Arora* 3753. Fruiting April.

Merremia aegyptia (Linn.) Urban. ; *Ipomoea pentaphylla* Jacq. ; FBI, 4 : 202.

Climber upto 2 m. high, stem hairy. Flowers with densely hairy calyx. Capsule ovoid, papery ; seeds light brown. Sidhi : Dubri. *Panigrahi* and *Verma* 5626. Gwalior : *Panigrahi* 5784. Flowers and fruits October to November.

M. tridentata (Linn.) Hall. f. ; *Ipomoea tridentata* Roth. ; FBI, 4 : 205.

Perennial herb with stout rootstock, in rock crevices near dam. Flowers pale yellow. Capsule round. Scarce. Shivpuri : Pabra Dam. *Panigrahi* 5831. Flowers and fruits November.

M. emarginata (Burm. f.) Hall. f. ; *Ipomoea reniformis* Chois. ; FBI, 4 : 206.

Creeper rooting at nodes, in alluvial soil. Flowers small, yellow with brown tinge. Capsule globose ; seeds brownish black, flattened. Abundant. Gwalior : Dabra. *Panigrahi* 5749. Raison-Seoni. *Panigrahi* 6252. Sidhi : Bastua, *Panigrahi* 2307. Flowers and fruits November to December.

M. vitifolia (Burm. f.) Hall. ; *Ipomoea vitifolia* Bl. ; FBI, 4 : 213.

Climber. Flowers yellow orange in colour. Scarce, Jagdalpur : Gidam-Bastanar. *Panighari* and *Arora* 1108. Flowers February.

Convolvulus microphyllus Sieb ex Spreng ; *C. pluricaulis* Choisy. ; FBI, IV : 218.

Perennial herb with a woody rootstock, branches prostrate or ascending, upto 60 cm. long ; in waste lands and rock crevices. Flowers light pink to white. Abundant. Rewa, *Hanfi* 1467. Shivpuri : Dabra. *Panigrahi* 5745. Gwalior : Pabra dam site. *Panigrahi* 5850. Morena : Kunnoo river bank. *Panigrahi* 5973. Flowers November to April.

C. arvensis Linn. ; FBI, 4 : 289.

Annual slender glabrous prostrate herb in wheat and barley fields on alluvial soil. Flowers pinkish-lilac-white. Abundant. Sidhi : Gerhwa. *Panigrahi* 2141. Raisen–Seoni. *Panigrahi* 6250. Flowers December to January.

Evolvulus alsinoides Linn. ; FBI, 4 : 220.

Perennial herb with numerous prostrate to ascending branches in wastelands to dry deciduous and sal forests ; on alluvial plains and in rock crevices ; young leaves and branches densely covered with white hairs. Flowers blue violet. Seeds brown. Abundant. Katni. *Panigrahi* 5035. Sidhi : Gandhigram. *Panigrahi* and *Verma* 5644. Shivpuri. *Panigrahi* 6071. Lalpur. *Panigrahi* 6224

Rorighat. *Panighari* 6534. Raipur. *Panighari* 6728. Bilaspur : Kathgora, *Arora* 3735. Sidhi : Majhauli. *Panigrahi* 2376. Flowers and fruits September to April.

Volvulopsis nummularia (Linn.) Roberty in Candollea XIV. 28, 1952. *Evolvulus nummularius* Linn.

Rootstock perennial, with annual trailing branches rooting at nodes ; in alluvial and rocky substratum ; young stem and sometime leaves—also sparsely hairy. Flowers white. Fruits brown. Abundant. Raipur. *Panigrahi* 5065, 5090. Jagdalpur : Kutumsar. *Panigrahi* 1169. Sidhi : Barkedol. *Panigrahi and Singh* 2173.

Porana paniculata Roxb. ; FBI, 4 : 223.

A large climbing shrub, in rocky bed near nala and in clayey loam soil. Flowers white, sweet smelling. Abundant. Gwalior : Takanpur. *Arora* 70. Sidhi : Garhwa. *Panigrahi* and *Singh* 2449. Flowers December to January.

Cuscuta reflexa Roxb. ; FBI, 4 : 225.

A leafless yellow twinning parasite in thorn forests and other places. Flowers sub-cylindric, creamy white. Capsule tough, fleshy. Abundant. Gwalior. *Panigrahi* 5777. Hoshangabad : Bhainsdehi. *Panigrahi* 4376. Flowers November.

Summary

This the third part of a series of communications on the flowering plants from Madhya Pradesh presents an enumeration of 74 species belonging to the families Ebenaceae to Convolvulaceae, following Bentham and Hooker's (1883) System. Notes on habit, habitat, colour of flower and fruit, abundance in the area, exact localities of occurrence, collectors' name and field nos. and lastly, flowering and fruiting seasons, are appended to every species.

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FURTHER STUDIES ON THE EFFECT OF CONCENTRATION OF NITROGENOUS SALTS ON THE FORMATION OF HETEROCYSTS IN THE CYANOPHYTA

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"Heterocysts", the specialized cells found in the Cyanophyta or the blue-green algae are structures which are very characteristic. They are found only in this group of plants and form an important feature used in the identification of the filamentous members. The exact function of the heterocysts, however, is not yet definitely known. Several theories have been advanced but all have proved inadequate to explain the phenomena connected with them. Fritsch (1951, p. 211) has labelled these structures 'botanical enigma' and Geitler (1960, p. 73) has opined that the hypothetical functions assigned to heterocysts have not been satisfactorily explained. This is due to a lack of adequate experimental data on their formation under controlled experimental conditions.

Borzi (1878), Kirchner (1900), Kohl (1903) and more recently Serpette (1948) are of the opinion that the heterocysts have some mechanical function with relation to the filament. Hieronymous (1892), Hegler (1901) and Fritsch (1904) thought of the heterocysts as storehouses of food material while Canabaeus (1929) was of the opinion that they contain enzymes. Brand (1901), Spratt (1911) Geitler (1921) and Desikachary (1946) regard the heterocysts as archaic reproductive bodies. In proposing his latest theory that heterocysts liberate some substance that promotes growth of other vegetative and reproductive cells, Fritsch (1951, p. 210) remarks that "it may prove to be another of the diverse untenable hypotheses put forward in the past".

In structure the heterocysts are somewhat larger but often also slightly smaller than the ordinary cells of the filament. They originate from a recently divided cell but during development undergo a process of differentiation distinct from other cells. There is some divergence of opinion about details of this change but broadly stated in the course of its maturity, the heterocyst usually enlarges and acquires a thicker wall composed mostly of cellulose. Its contents become hyaline or pale blue-green after disappearance of granules, which process is often accompanied by the appearance of vacuoles. The last process is irreversible and has been interpreted as heralding death or the structures becoming seats of salt accumulation. By this time one or two polar nodules, according as the heterocyst is terminal or intercalary, appear at the point of attachment to the other cells of the filament. Frequently the heterocyst appears empty or as having a homogeneous viscous substance. It is incapable of secreting a mucilaginous sheath and in many forms may become entirely disconnected from the filament.

Most of the theories mentioned above have been formulated by their authors on observations of material collected from nature and only a few workers have in recent years tried to base their opinions on experiments. Canabaeus (1929) found that in presence of 0·2% sodium chloride and other halides in the medium the frequency and size of heterocysts in *Anabaena variabilis* increased three times.

Fogg (1944, 1949) after extensive experimentation with *Anabaena cylindrica* concluded that the frequency of heterocysts varied with the age of the alga and was inversely related to the concentration of combined nitrogen in the filament. Their numbers were decreased by ammonium salts.

Mitra (1947) observed total absence of heterocysts in *Tolypothrix arenophila* W. *et.* G. S. West (=*Camptylonema lahorense* Ghose) when grown in De's (1939) medium and their places were often taken by biconcave separation discs. Pandey and Mitra (1959) found after extensive experimentation that depletion of nitrogen-concentration of the medium irrespective of the source being nitrate or ammonium salts was responsible for production of the heterocyst. Pandey and Mitra (1962*b*) working with *Anabaena naviculoides*, *A. cycadeae*, *Anabaenopsis ambigua*, *Scytonema praegnans* and *Fischerella muscicola* obtained the same results showing this effect to hold good for many heterocystous algae.

Material and Method

Pure cultures prepared with the help of ultraviolet radiation coupled with growth on silica-gel plates of *Scytonema hofmanni* and unialgal cultures of *Nostoc sphaericum*, *Anabaena naviculoides*, *Calothrix membranacea*, *Tolypothrix arenophila* and *Mastigocladus laminosus* were used. Taking De's medium as base, experimental substrata were prepared and the size of the inocula was kept as uniform as possible with the help of an 'inoculum-cutter'. Cultures were made in triplicate in 150 ml. Erlenmeyer flasks and kept for 60 days at room temperature (25°C± 2°C) near a battery of 40 watt electric bulbs yielding an intensity of light amounting to 400 lux. The amount of nitrogen supplied was kept higher than the critical concentration required for production of heterocyst for each alga.

Results

Effect of hydrogen-ion concentration.—Variation of pH of the following order 5·2, 5·4, 6·0, 6·4, 7·0, 7·6, 8·5, and 8·9 obtained with K_3PO_4 and KH_2PO_4 using a Beckmann's pH meter, did not influence heterocyst production.

Effect of temperature.—Temperature variation of 15°, 20° and 35°C did not affect production of heterocysts.

Effect of light intensity.—Variations of light intensity of 100, 200, 300 and 400 lux did not influence production of heterocysts in any way.

Effect of addition of trace elements and riboflavin.—Addition of Hutner's A-Z trace elements solution (1950) alone or with riboflavin in amounts varying from 1 to 30 ppm., proved ineffective in influencing production of heterocysts in any manner.

Effect of addition of calcium chloride and sodium chloride.—Calcium chloride in concentrations of 0·005, 0·01, 0·05, 0·1 and 0·3 gm/L and sodium chloride varying from 0·1, 0·5, 1·0 and 2·0 gm/L did not affect the formation of heterocysts.

It thus appeared from the foregoing experiments that so long as the concentration of nitrogen in the medium remained above the critical value for the different algae used there was no formation of heterocysts with the variations of growth conditions mentioned above. Heterocysts, however, were formed under the above conditions when the amount of nitrogen in the medium fell below the critical concentration after prolonged growth as was determined with the help of micro-Kjeldahl apparatus using the filtrate after the appearance of heterocysts.

Experiments conducted with *Mastigocladus laminosus, Calothrix membranacea, Scytonema hofmanni* and *Nostoc sphaericum* with different concentrations of potassium nitrate and ammonium nitrate have given the results tabulated in Table 1.

TABLE 1

Showing the residual nitrogen in the medium at the appearance of heterocyst and the interval in days elapsed after inoculation and the source and amount of nitrogen supplied to the cultures of the four named heterocystous forms

Alga	Salt	Nitrogen in mgm/100 ml.	Days	Residual nitrogen in mgm/100 ml.	
Mastigocladus laminosus	KNO$_3$	22·08	21	7·022	6·916
	NH$_4$NO$_3$	56·00	26	6·81	
Calothrix membranacea	KNO$_3$	22·08	22	8·20	8·12
	NH$_4$NO$_3$	56·00	28	8 04	
Scytonema hofmanni	KNO$_3$	22·08	19	11·2	11·04
	NH$_4$NO$_3$	56·00	28	10·88	
Nostoc sphaericum	KNO$_3$	22·08	19	10·7	10·5
	NH$_4$NO$_3$	56·00	25	10·3	

It is seen from the above table that the residual nitrogen in the medium is nearly similar whether potassium nitrate or ammonium nitrate is used and this amount may be taken as the critical concentration of the nitrogen in the medium necessary for the formation of heterocysts in these algae when the above salts are used. Working with inorganic sources of nitrogen Pandey and Mitra (1962b) obtained similar results and observed in the case of several other forms that the nitrogen content of the medium at the point of heterocyst-production was almost the same with nitrates, but this was usually slightly lower with ammonium salts. A perusal of figures in Table 1 shows that in the present experiment also the figures for residual nitrogen with ammonium nitrate are slightly lower.

Effect of supplying organic sources of nitrogen.—An experiment was performed using different doses of urea and noting the period required for the appearance of heterocyst in *Tolypothrix arenophila* and *Anabaena naviculoides*. The result is tabulated in Table 2.

TABLE 2

Showing the effect of different doses of urea on the appearance of heterocysts in the algae mentioned. Appearance of heterocysts was on the days indicated. Duration of experiment was fifteen days

Alga	0·13 gm. urea equivalent to Nitrogen/L	0·013 gm Nitrogen/L	0·0027 gm Nitrogen/L	0·008 gm Nitrogen/L
Anabaena naviculoides	14th day	7th day	3rd day	3rd day
Tolypothrix arenophila	×	×	14th day	7th day

The results indicated a similar trend as was obtained with inorganic sources of nitrogen. *T. arenophila* showed heterocysts at a much lower concentration of nitrogen in the medium than *A. naviculoides*.

An experiment was performed to see if forms like *Oscillatoria* or *Lyngbya* which do not form heterocysts could be induced to form these structures, in very low concentrations of nitrogen. *Oscillatoria formosa* and *Lyngbya hieronymusii* were grown in media containing 0·01 to 0·1 gm KNO_3/L. None of these formed heterocyst even after a month and by that time many of cultures died for want of sufficient nitrogen supply.

Discussion

The work done so far points to the existence of a critical concentration of nitrogen in the medium, above which heterocysts are not produced. This concentration varies with different algae. Wide variations of other factors did not influence their appearance. Canabaeus (1929) found halides to increase the frequency of heterocysts in *Anabaena variabilis*. In the present work, however, variations of NaCl and $CaCl_2$ did not affect heterocyst production. Fogg's (1949) generalisations are broadly applicable to these experiments but with the forms employed here many are the differences observed as there was no production of heterocysts under low light-intensity and other factors so long as the concentration of nitrogen in the medium remained above the critical level.

The presence or absence of heterocysts is very important from the point of view of taxonomy and several similar genera like *Scytonema* and *Plectonema* or *Calothrix* and *Homoeothrix* and also a few others are distinguished on this basis. It is yet to be seen if all the heterocystous Myxophyceae respond in a similar manner to the nitrogen status of the medium and if this proves to be the case the emphasis so far placed on these structures has to be re-examined in relation to the nitrogen supply in the environment.

Summary

Heterocysts in some heterocystous filamentous forms of the Cyanophyta belonging to the Nostocaceae, Rivulariaceae, and Mastigocladaceae were prevented from being formed by keeping the level of nitrogen in the medium above the critical concentration. This critical concentration has been determined for the forms experimented with.

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OBSERVATIONS ON THE FISH AND FISHERIES OF THE VEMBANAD BACKWATERS, KERALA

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Introduction

Bordering the coastline of Kerala there are a large number of backwaters, which are connected with the sea by some permanent and some periodical openings and which in association with the adjoining low-lying lands, paddy fields and the network of canals form an extensive source of year-round fish supplies. They are also believed to be the nursery grounds of several species of prawns and fishes of commercial importance and hence afford a rich source of prawn and fish seed. But the recent development of reclamation projects in these areas pose a problem, in that they are likely to have adverse effects on these resources. Further, according to Panikkar (1952) there has been a most marked 'depletion' of the fisheries in the backwaters, canals and low-lying areas in Travancore, owing probably to the intensive fishing that has been going on without replenishment having taken place. Earlier, John (1936) had referred to the indiscriminate fishing methods and lack of Government control, which tend to lead to decline in fish populations by destroying breeders and fry.

But, as yet there is no scientific information on the status of the fisheries in these waters, except for some fragmentary accounts regarding the bionomics of some fish (Bhaskaran, 1946), or the species available (Day, 1855; Pillay, 1929; John, 1936; Silas, 1949, etc.). Only the prawn fisheries have been fairly extensively studied by a number of workers, notably Menon (1951, 1954, 1955, 1957 and 1958), Menon and Raman (1961), Panikkar and Menon (1955), Gopinath (1953), Panikkar (1937), and Chopra (1943), while accounts of several fishing gear used in these waters have been given by Hornell (1937 and 1950), Gopinath (1953) and in a Government of India publication (1951).

Therefore, a preliminary survey of the largest piece of Kerala backwaters, the Vembanad backwaters, was undertaken during March 1959, in order to obtain a general idea of its fisheries and to identify the problems requiring investigation.

Hydrographical Features

The Vembanad backwaters extend from Cranganore in the north to Alleppey in the south, a distance of about 96·5 km (*see* map). The total area of this water mass, as shown in the Survey of India map, is roughly 300 sq km. But an area of about 44 sq km at its south-eastern corner near Alleppey was found to have already been reclaimed at the time of survey, thereby reducing the total area to about 256 sq km. The northern portion of the backwaters above Aroor is situated in the erstwhile Cochin State and is generally referred to as the Cochin backwaters, while the southern portion, termed normally as the Vembanad lake, lies in the erstwhile Travancore State. In view of the continuity of this water mass right upto Cranganore, the entire stretch is referred here as the Vembanad

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backwaters. The southern portion of the Vembanad backwaters is much broader, while the northern portion is narrower and sinuous. The lake runs parallel to the Arabian Sea, to which it is connected in the main at two places, at Cochin and Azhikode, both in the northern half. Branching off from the main stretch of backwaters are a number of subsidiary water masses and canals.

Except at Cochin, where dredging is carried out to facilitate the movement of ships, these backwaters are essentially shallow, with the depth in the fishing grounds varying from one metre to 7·75 metres, with a mean depth of about 3·5 metres. Below Munro Island at its southern part, the lake is quite shallow, the depth on an average being just two metres only. It is a little deeper between Thannirmukham and Vaikom (about 5 metres) and for some distance north of Cochin. The nature of the bottom is mostly muddy, with an admixture of fine sand granules in some places. Off Kumaragam the bottom consists of mud with a thick deposit of sub-fossil lamellibranch shells, while off Aroor, Manapilli and Azhikode it is sandy.

Since both connections to the sea are situated in the northern half of the backwaters, that section is much more saline than the southern half. At the time of survey, the water above Chembu-Panavalli area up to Azhikode showed a salinity range varying from 23·31%₀ to 33·55%₀, with the maximum at Cochin, while the waters below Vaikom showed a gradual decline southwards from 18·44%₀ at Vaikom down to 10·49%₀ at the southernmost end of the lake off Alleppy. Panikkar (1937) has stated that these waters become almost fresh and are in a flooded condition from June to September during the south-west monsoon and that the water level falls considerably after the north-east monsoon during November, and by December the water is distinctly brackish. He further states that optimum conditions for the life of brackishwater animals are obtained in these waters from January to March. Local enquiries revealed that the waters south of Thannirmukham remain quite fresh during the period of south-west monsoon.

The depth and salinity of the water and the nature of the bottom in different parts of the backwaters, at the time of survey, are shown on the map.

The discharge of effluents from the F. A. C. T. factory in Alwaye is believed to contaminate these backwaters, although the extent of this pollution does not seem to have been determined so far. A second likely source of pollution is the coconut husk retting, which is done on a large scale at certain places like Palangad, where the water appears darkish, with apparently high turbidity. At the southern end of the lake off Alleppy, immense quantities of filamentous algae (*Oedogonium* sp. ?) were noticed and these were found to hamper the operation of big nets like *Peru vala* by clogging the meshes and making the hauling process very difficult.

Commercially Important Fishes and Prawns

A classified list of all the fishes, prawns and crabs collected during the survey is given in the Appendix. Among those of major commercial importance contributing to rich fisheries may be mentioned three species of prawns (*Metapenaeus dobsoni, M. monoceros* and *Penaeus indicus*) and five species of mullets (*Mugil cephalus, M. cunnesius, M. parsia, M. troscheli* and *M. waigiensis*) in the upper half of the backwaters above Arukutty, and Cock-up (*Lates calcarifer*), Milk fish (*Chanos chanos*) and Pearlspot (*Etroplus suretensis*) in the lower half. In addition to these, the sciaenid *Sciaena coiter*, the perch *Lutianus argentimaculatus* and the catfishes *Tachysurus* spp. are found in good numbers all along the backwaters. Among those

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of lesser commercial importance may be mentioned *Caranx sansun, Tylosurus strongylurus, Hemiramphus cantori, Etroplus maculatus* and *Scatophagus argus* in the lower stretches and *Thrissocles* spp., *Anchoviella* spp. and *Eleutheronema tetradactylum* in the upper stretches. The occasional occurrence of Hilsa *(Hilsa ilisha)* in shoals in these waters has already been reported by Pillay (1960).

Of the above, the Pearlspot is reported to be available in its maximum numbers during the rainy season, while maximum catches of the Cock-up are obtained from January to April. The catfish *Tachysurus arius* is reported to be fished from December to March, with the maximum catches obtained during February and March. The fishery for Beloniform fishes extends mainly from December to March, while the Milk fish is reported to be available in good numbers from November to June. The major prawns, being marine species, enter the backwaters as young ones along with tides in search of food, grow there and return to the sea for spawning. They are caught in their maximum numbers during the months September to February. The rare occurrence of Hilsa reportedly coincides with the high salinity period during March and April.

Fisheries and Fishing Operations

The commercially important fishes and prawns are fished in a variety of gear. An account is given below of the various fishing operations, with the emphasis laid more on the magnitude and composition of the catches and the distribution of the gear, rather than on the description of the gear or on their mode of operation.
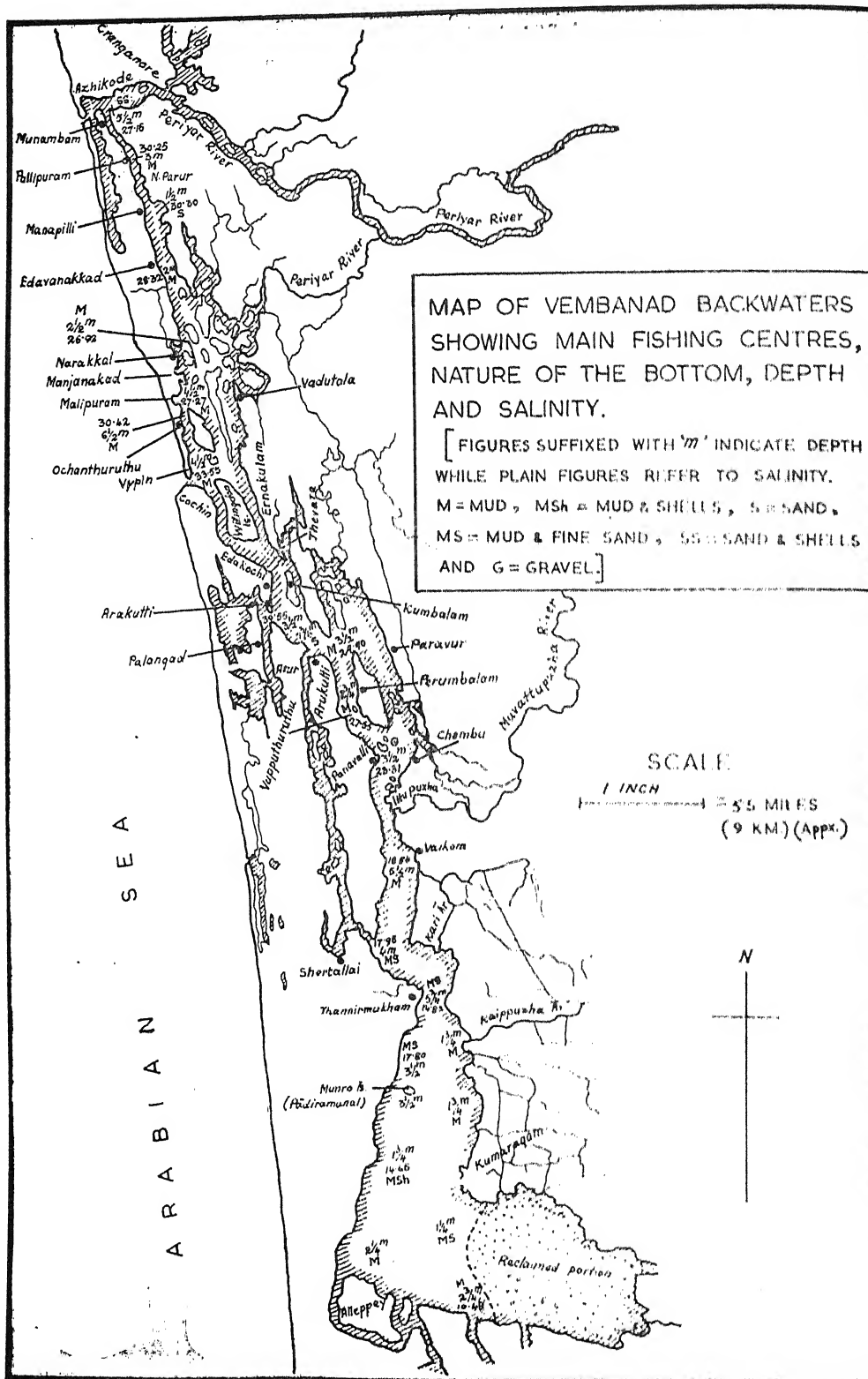
(a) *Dip net and Stake net fisheries*

The most striking feature of these backwaters is the extensive dip net and stake net fishing found all along the stretch above Thannirmukham. These nets are essentially operated for prawns and mullets, which contribute to the most important commercial fisheries in the northern half of the backwaters. They are absent below Thannirmukham, because of the lack in that region of strong tidal currents, which are necessary for the successful operation of these nets.

(i) *Dip net fishery*

The net employed is generally known as the Chinese dip net or *Cheena vala* or *Kamba vala*. It is a stationary balanced lever dip net, located singly or in groups both along the shore and near the shore in shallow waters. The structure and, mode of operation of this net have been adequately described by Hornell (1937), Panikkar (1937) and others. It is operated at nights mainly for prawns and during the day mainly for mullets. During the night operations, a petromax is tied just above the net to attract the prawns. The time of operation is usually at the turn of the tide from low to high, when the current is best felt. The greatest concentrations of this net are at and adjacent to the two openings of the lake into the sea at Ernakulam and Azhikode. At Azhikode, these nets extend even into the sea for some distance (about a furlong) along the shore, south of the Periyar river mouth. Rows of them can also be seen on either side of a narrow stretch of backwaters (about six miles long), west of the main backwater mass, running southwards from the Periyar river mouth.

The night catches consist essentially of large and medium sized prawns, (mainly *Metapenaeus dobsoni, M. monoceros* and *Penaeus indicus*), with a sprinkling of several species of fish and at times even crabs and cuttle-fish. Among these may be mentioned the Sciaenids (*Pama pama, Sciaena* spp.), catfishes (*Tachysurus* spp., *Mystus* spp., etc.), clupeoids (*Thrissocles* spp., *Anchoviella* spp., *Megalops cyprinoides*), *Ambassis* spp., *Leiognathus* spp., *Eleutheronema tetradactylum, Neptunus pelagicus* and *Scylla serrata.*

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MAP OF VEMBANAD BACKWATERS
SHOWING MAIN FISHING CENTRES,
NATURE OF THE BOTTOM, DEPTH
AND SALINITY.

[FIGURES SUFFIXED WITH 'm' INDICATE DEPTH
WHILE PLAIN FIGURES REFER TO SALINITY.
M = MUD, MSh = MUD & SHELLS, S = SAND,
MS = MUD & FINE SAND, SS = SAND & SHELLS
AND G = GRAVEL.]

SCALE

1 INCH = 5·5 MILES
(9 KM.) (Appx.)

N

ARABIAN SEA

Cranganore
Azhikode
Munambam
Pallipuram
Manapilli
Edavanakkad
Narakkal
Manjanakad
Malipuram
Ochanthuruthu
Vypin
Cochin
Edakochi
Arakutti
Palangad
Vypputhuruthu
Atur
Panavelli
Arakutti

Periyar River
N. Parur
Vadutala
Ernakulam
Thevara
Muvattupuzha River
Kumbalam
Paravur
Perumbalam
Chembu
Chithira Puzha
Vaikom
Shertallai
Thannirmukham
Kaippuzha Ar.
Munro Is.
(Pudiramunal)
Kumbragom
Reclaimed portion
Alleppey

The day time catches consist mainly of mullets (*Mugil parsia, M. waigiensis, M. troscheli, M. cunnesius* and *M. cephalus*), the others present in lesser numbers being *Eleutheronema tetradactylum, Scatophagus argus, Thrissocles* spp., *Anchoviella* spp., *Megalops cyprinoides*, sciaenids and catfishes. The mullets dominate the catches specially in the Cochin part of the backwaters. It is gathered that the night prawn catches by this net are at their maximum from November to February and that the daily catch may go up to as much as 100 lbs. per net.

(ii) Stake net fishery

The stake net is a type of fixed conical bag net with a tapered cod-end, resembling the *Been-jal* of Bengal, about 20–25 ft. in length. It is locally known as the *Kutti vala* or *Valu vala*. A full description of its structure has already been given by Hornell (1937). Usually a series of these nets are tied up to stakes planted across the backwaters, with one net between every two stakes.

This net is permitted to be operated only during the ebb tide, in order to prevent the destruction of young ones of prawns entering the backwaters. It is usually operated at a depth of about 3–5 metres and fishing goes on practically throughout the year. It is, however, mentioned by Menon (1955) that stake net fishing remains suspended when there are high floods during the monsoon months June–August, because of the likelihood of swift currents and floating debris damaging the nets. The daily catch varies from a few pounds to about 50–60 lbs. in favourable seasons. The prawns form the bulk of the catches and it is gathered that they are obtained in their maximum quantities during September and October. The main species of prawns fished by this net are *Metapenaeus dobsoni, Penaeus indicus* and *Metapenaeus monoceros*. The fish caught in this net consist mainly of clupeoids (*Anchoviella* spp. *Thrissocles* spp., *Anodontostoma chacunda*, etc.) and gobeids. Occasionally eels, Squilla, Sepia and Octopus are also found in the catches.

(b) Other fisheries

Besides the above two principal fishing gear, which belong to the "fixed engine" category, several others falling under the "free engine" category are operated for different fishes and prawns. In addition to these, several people are engaged in extensive clam and shell fisheries and paddy field prawn fishery.

(i) Cast net fishing

Fishing with cast nets ('*Vecchu vala*') goes on throughout these backwaters, but is specially concentrated in the upper stretches. All along from Narakkal to Edavanakkad, the stringed variety of cast nets was seen being operated in large numbers in shallow areas, which are reported to have flat bottom and hence more suitable for operation of small cast nets. Concentrations of this net were also observed from Manapilli to Cherai and at Parur, Pallipuram and Azhikode in the upper stretches and in the lower stretches at Arukutti, Kumaragam and Alleppey.

The catches in the upper stretches consist mainly of metapenaeid prawns, with also a few mullets, engraulids and sciaenids. In the lower stretches, where generally bigger-meshed cast nets are employed, Pearlspots constitute the bulk of the catches, the others being half-beaks, gobeids, etc. The daily catch is said to vary from 10–80 lbs. and occasionally even upto two maunds, the average daily catch being about 15 lbs. It is gathered that the catches are the heaviest during the spring tides.

(ii) Canoe-trap fishing

A kind of canoe-trap, termed locally as the *Changalapayikkal* or *Changadam* is in use in the middle and upper stretches of the Vembanad backwaters, operating in shallow regions during calm periods, for catching prawns and grey mullets,

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This method of fishing is based on a knowledge of the habits of some prawns and mullets, which when frightened leap wildly out of the water.

Several workers like Hornell (1937 and 1950), Panikkar (1937) and Gopinath (1953) have given full descriptions of *Changādam* and its mode of operation. However, there are differences in these accounts regarding the dragging device, which, as per the author's observations, consists of a chain attached to the bow of each boat, with the two chains joined together posteriorly. But according to Gopinath (*loc. cit.*), it consists of a single long chain, with its two ends attached to the two boats, while Hornell (1937 and 1950) and Job and Pantulu (1953) have described it as consisting of short pieces of chains, connected by lengths of rope. Further, according to Panikkar (1937) and Chopra (*op. cit.*), it is a net that is tied across between the two canoes and not any chain, and the prawns trying to swim through are trapped in this net. This may probably be a local variation at the place and time of observation. Again, it is stated by Panikkar (1937), Gopinath (1953) and Menon (1955) that only prawns and shrimps are caught by this method. But as per information gathered during the present survey, even though prawns constitute the main catch, mullets are also obtained occasionally. Hornell's (1937 and 1950) accounts confirm this observation.

(iii) Drag net fishing

Drag net fishing is again resorted to mainly for catching prawns, along with which a few miscellaneous fish like *Anchoviella* spp., *Ambassis* spp., *Etroplus* spp., gobeids, half-beaks, etc. are also caught. The drag net commonly seen in these waters is known as the *Vadi vala*. It is a trough-shaped drag net, resembling the *Khadijal* of Orissa. It is generally seen in the middle and lower stretches from Arukutti down to Thannirmukham in the main backwaters, as well as in the connected canals. The details of its structure have already been described by Hornell (1937). It is operated either singly or in groups of two throughout the year during both night and day at the time of low tide. The catch is mostly dried and sold later on.

(iv) Bag net fishing

A kind of bag net called the *karimeen vala* is seen in the lower stretches operating for about six months in a year from January to June catching Pearlspots. Mullets and prawns are also caught in lesser numbers. It is a conical bag net, 18 ft. long and 24 ft. across its mouth. It is made of cotton yarn, with the mesh size varying from $1\frac{1}{2}''$ near the mouth to $\frac{4}{8}''$ at the cod end. Fishing is done during both the tides. The net is fixed to the bottom by two stakes and is hauled up after about 30–45 minutes. There are floats on the upper half of the mouth and sinkers on the lower half. There is no opening at the cod end of the net.

(v) Trawl net fishing

One kind of trawl net called *Konchi vala* operates in the middle stretches near Arukutti for cathing big prawns and fish. It consists of a rectangular bag 25 ft. long and 54 ft. across, made of 36 no. cotton yarn, with a mesh size varying from $1\frac{1}{2}''$–$2''$. During operation this bag is dragged along by two boats, the mouth being kept distended by floats on the upper half and sinkers on the lower.

(vi) Seine net fishing

Several kinds of boat seines are operating all over these backwaters for catching a variety of fishes. Among these the *Telikanni vala* and *Pattikanni vala* are the most common. Both are provided with long scare lines of tender coconut leaves and are of similar structure, with only the mesh size of the latter being

smaller. The catch consists of a number of fishes, among which may be mentioned *Caranx sansun*, *Therapon puta*, *Etroplus* spp., mullets, clupeoids, sciaenids and prawns. The smallest meshed (½″) *Pattikanni vala* is without the scare lines and is used for catching prawns and hence termed *chammeen vala*. Part of the operation of this net consists of dragging it with two poles and this probably accounts for Hornell's (1937) inclusion of *Telikanni vala* and *Pattikanni vala* under drag nets. Maximum catches by *Telikanni vala* are reportedly obtained during the rainy season.

In the middle and lower stretches can be seen an interesting method of fishing by *Koori vala*, wherein the sounds produced by moving shoals of fishes are made use of for locating their whereabouts and extent. This type of fishining has been fully described recently by Gopinath (1953), who terms it "fishing by listening in". According to him, one of the two fishermen gets into the water and immerses his head in the water, while according to the auhtor's observations the fisherman sits inside the boat and by bending over immerses his head in the water. The net is generally used as a seine, but at times also as a gill net set across the path of shoals. The catch consists essentially of *Tachysurus* spp. and occasionally some sciaenids. Surprisingly, Gopinath (*loc. cit*) has not mentioned catfishes among the catch of this net. Heavy catches are reportedly obtained during February—March and the rainy season.

A big 1″ meshed boat seine called *Peru vala* is operated in the lower stretches throughout the year. The catch is miscellaneous, consisting of a number of fishes and a few prawns. This net is payed out in concentric circles and is hauled up in such a way that those of the fishes which are not gilled are encircled and brought up.

(vii) Gill net fishing

A large number of gill nets are operated throughout the year, mostly in the lower stretches. Among them may be mentioned the *Narimeen vala*, *Odu vala* or *Poomeen vala*, *Thiruda vala*, *Morashu vala* and *Chavala vala*. The *Narimeen vala* for catching *Lates calcarifer* is a big net of 6″ mesh size, operated generally during the months February to April at nights. The same net is used in the rainy season for catching skates and rays, by altering the mesh size to 12″. The *Odu vala* is a similar net, but with smaller mesh (3″) and is operated throughout the year. The catches consist essentially of *Chanos chanos* and *Lates calcarifer*, with also a good number of *Mugil cephalus*, *Scatophagus argus*, *Lutianus argentimaculatus* and *Sciaena coiter*. The *Thiruda vala* or *Paithu vala* is a stationary gill-net for catching *Mugil cephalus*. *Morashu vala* is another kind of stationary surface gill net in the lower stretches for catching *Hemiramphus* and *Tylosurus*. It is mainly operated during the months January to March, when these fishes are reported to be available in their maximum numbers. *Chavala vala* is a drifting gill net operated at nights during the rainy season and the catch is similar to that of *Odu vala*.

(viii) Clam fishery

Large numbers of live clams are available in these backwaters from a little to the south of Munro Island down to Alleppey and these are fished by a good number of lower stretch fishermen. The catch is generally taken to their respective villages, where the clams are boiled, the flesh taken out and sold to consumers, and the empty shells sold mainly to people preparing lime and to the Travancore Cement Factory. The shells are also reported to be used in house construction and maintenance works, while half-burnt shells and lime are extensively used to counteract acidity in paddy fields and lands.

(ix) Shell fishery

In addition to clam fishery, a large number of people are engaged in collecting the sub-fossil deposits of lamellibranch shells, found in the backwaters from Thannirmukham down Alleppey. The shells, belonging mainly to the genera *Meretrix* and *Vellorita*, are given to the cooperative societies at Kumaragam, Mohamma, Vechchur, Kuttamangalam, etc., which sell them to people preparing lime or to the cement factory. These shells are utilised in house construction works and for counteracting acidity in paddy fields. In addition to the above people, the public sector cement factory at Kottayam is also collecting the shells for the manufacture of cement. It is reported that annually about 50 lakhs tons of shells are collected from the Kerala backwaters, with the season lasting from August to May, the peak period being January to March (Director of Fisheries, Kerala, 1961).

(x) Paddy field prawn fishery

In addition to the rich backwater fisheries for them, the prawns are also cultured extensively in about 8,000–10,000 acres of paddy fields bordering the Vembanad backwaters (Gopinath, 1955). The annual production from these fields has been estimated as ranging from 3,100–5,400 tons, of which prawns form about 80%, with an average yield of 360–680 kg per acre (Director of Fisheries, Kerala, *op. cit.*) The highest yield is reportedly obtained in the Parur and Cochin-Kanayannur taluks in the northern sector. Further details become superfluous in view of the detailed accounts already given by Menon (1954) and Gopinath (1955).

Disposal of catches and Administration of fisheries

Except at Cochin Port area, where it is prohibited, fishing is done practically all over the backwaters. There are hardly any regular landing places, the catches being mostly disposed off anywhere near the fishing grounds, mostly in fresh condition, to individual consumers. Only when the catch consists of very small prawns, it may be sun-dried and sold later on. However, in some places like Cochin, Vaikom, Kumaragam and Alleppey the catches are mostly sold to merchants. At Cochin, big and medium sized prawns are purchased by the Freezing and Canning Companies for exporting them to foreign countries.

Day in his "Fishes of Malabar" (1865) has observed that at that time there was no tax upon fishermen or on their implements of trade either in the "British territory or in native State of Cochin," while previously the fishermen had to pay for their fishing rights either in kind or by way of taxes or both. At present the fishing rights in the Vembanad backwaters are controlled by a system of leasing and licensing. The main stretch of the backwaters, as also the major subsidiary masses are not leased out, but the fishing gear operating in them are licensed. The only type of, rather indirect, leasing in these waters is in connection with the fixed engines, wherein the places allotted for their operation are fixed and cannot be changed. But here also a certain licence fee is charged for each operating net. It is gathered that even if the Government wants to take over such locations, due compensation will have to be paid to the licensee and that the right of erecting stake nets in any particular area is hereditary.

The licence fee levied varies with the type of gear and the area of its operation. The licence fee for stake and dip nets is higher in areas where there is greater tidal influence. Similar licensing is resorted to with regard to the prawn-culturing paddy fields, where also the magnitude of the licence fee depends on the nature of the field and the tidal conditions in the adjoining backwaters. Gopinath (1955)

has given a detailed account of the classification of these fields and the licence fee levied by the Government.

Certain canals and minor subsidiary backwater masses are annually leased out by public auction. The lessees might themselves fish in these waters, in which case no separate licence fee is payable to the Government for the gear operated. At times, the lessees sublease these waters to others, from whom some fee is obtained for the gear operated.

Major investigational problems

For a proper utilisation of these important backwaters with regard to the management and conservation of their fisheries, it is necessary to undertake some major investigations on a systematic basis.

(1) In the first place, there must be a suitable machinery for the collection of fishery statistics, for estimating total production, catch-per-unit of effort, etc., data on which will be necessary before formulating any development measures.

(2) The suspected depletion of the fisheries of these backwaters requires immediate detailed investigation. Panikkar (1952) had reported that many areas which previously used to yield appreciable numbers of *Etroplus* had ceased to be so. Enquiries made during the survey revealed that there has been a progressive reduction in the maximum size of *Etroplus* in the lake, which is almost a sure sign of depletion. Further to taking suitable measures to improve the *Etroplus* fishery, it may be worthwhile considering implementation of Panikkar's (*loc. cit.*) suggestion of introducing omnivorous feeders, which can tolerate wide variations in salinity and can reproduce more rapidly than *Etroplus*.

(3) The probable effects of reclamation projects on the fisheries should be ascertained. There are possibilities of the breeding, nursery and feeding grounds of some commercially important species of fishes and prawns getting destroyed by extensive reclamation. This will directly affect the prawns and fish seed source, as well as the paddy field prawn culture, in addition to reducing the production potential of the lake itself.

(4) It is imperative to investigate the extent of pollution of these backwaters, resulting from the discharge of effluents from the F. A. C. T. factory, Alwaye and from coconut husk retting in different areas and their effect on fish populations.

(5) It would be interesting to study the effects of stake net fishing on the commercial fisheries of the lake, as well as of the sea. The net being small-meshed, appreciable quantities of commercially unimportant smaller size groups are caught and this may adversely affect some of the commercial fisheries.

(6) Suitable means must be worked out either to discourage the growth or for the removal of the huge quantities of filamentous algae (*Oedogonium* spp. ?) found near Alleppey, to facilitate easy operation of certain big nets like *Peru vala*, unless these algae form the food of any commercially important fishes. In addition to physically hampering the operation of *Peru vala*, these algae, by clogging the meshes of the nets, bring about the destruction of considerable numbers of fry which are unable to escape. In this connection, it may be mentioned that Cervenka *et al.* (1959) had tried compounds of copper, silver and sodium pentachloro-phenolate to prevent excessive increase of phytoplankton in Sedlice reservoir.

(7) Finally, the study of population dynamics and biology of the commercially important species of prawns and fishes would be of immense help in the management of the backwater fisheries.

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Summary

A rapid survey of the Vembanad backwaters in Kerala was carried out in March 1959, in order to obtain a general idea of its fisheries resources and to identify the problems requiring investigation.

These backwaters are connected to the sea in two places, both in the northern half, which therefore shows more pronounced salinity and tidal conditions. The mean depth is about 3·5 metres and the bottom is mostly muddy. There is apparently some pollution of waters by the effluents of the F. A. C. T. Factory, Alwaye and by the coconut husk retting in the some places.

Prawns and mullets dominate the northern half of the backwaters, while the Cock-up, Milk fish and Pearlspot predominate in the southern half. Fishing is done practically all over the backwaters throughout the year. There are no regular landing places and the catches are mostly disposed off in fresh condition. Big-sized prawns are exported to foreign countries by the freezing and canning companies.

Dip nets and stake nets are extensively operated mainly for prawns and the former for mullets also, while a variety of other nets are used for catching these and other fishes. Live clams and sub-fossil lamellibranch shells are fished extensively in the southern half. Prawns are cultured on a large scale in the paddy fields adjoining these backwaters.

The fishing rights are controlled by a system of leasing and licensing. For a proper management of the fisheries resources, it is necessary to undertake some detailed investigations like the collection of catch statistics, population dynamics and biology of commercially important species and the probable effects of reclamation projects and water pollution on the fisheries.

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APPENDIX

Classified list of fishes, prawns and crabs of the Vembanad Backwaters, recorded during the survey

(Malayalam names, wherever known, are indicated within inverted commas)

FISHES*

Class ELASMOBRANCHI.   Subclass SELACHII
  Order LAMNIFORMES   Suborder SCYLIORHINOIDEI
    Family SCYLIORHINIDAE
      1. *Chiloscyllium indicum* (Gunther)

Class TELEOSTOMI.   Subclass ACTINOPTERYGII
  Order CLUPEIFORMES
    Suborder CLUPEOIDEI
      Family MEGALOPIDAE
        2. *Megalops cyprinoides* (Broussonet)

    Family CLUPEIDAE
      3. *Kowala coval* (Cuvier)
      4. *Hilsa ilisha* (Hamilton)   ..   "Vālava"
      5. *Anodontostoma chacunda* (Hamilton)   ..   "Thodi"
      6. *Nematalosa nasus* (Bloch)
      7. *Dussumieria hasselti* Bleeker   ..   "Kokolichāla"

    Family ENGRAULIDAE
      8. *Thrissocles purava* (Hamilton)   ..   "Challa"
      9. *Thrissocles malabaricus* (Bloch)   ..   do
     10. *Thrissocles mystax* (Schneider)   ..   do
     11. *Anchoviella indica* (van Hasselt)   ..   "Koluva"

    Suborder CHIROCENTROIDEI
    Family CHIROCENTRIDAE
     12. *Chirocentrus dorab* (Forskal)

    Suborder CHANOIDEI
    Family CHANIDAE
     13. *Chanos chanos* ((Forskal)   ..   "Poomeen"

  Order CYPRINIFORMES
    Suborder CYPRINOIDEI
      Family CYPRINIDAE
     14. *Barbus ticto* (Hamilton)

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*The classification followed upto the families is that of L. S. Berg ["Classification of fishes, both recent and fossil" *Trav. Inst. Zool. Acad. Sci. URSS*, 5 (2), 1940].

Suborder SILUROIDEI
  Family ARIIDAE (Tachysuridae)
      15. *Tachysurus macronotacanthus* (Bleeker)
      16. *Tachysurus falcarius* (Richardson)
      17. *Tachysurus subrostratus* (Cuv. & Val.)
      18. *Tachysurus arius* (Hamilton)
      19. *Tachysurus coelatus* (Cuv. & Val.)
  Family BAGRIDAE
      20. *Mystus (Mystus) gulio* (Hamilton)
      21. *Mystus (Mystus) armatus* (Day)
Order ANGUILLIFORMES
  Suborder ANGUILLOIDEI
    Family MURAENESOCIDAE
      22. *Muraenesox cinereus* (Forskal)
    Family OPHICHTHYIDAE
      23. *Ophichthys microcephalus* (Day)

Order BELONIFORMES
  Suborder SCOMBEROSOCODEI
    Family BELONIDAE
      24. *Tylosurus strongylurus* (van Hasselt)   . .   "Kola"
Suborder EXOCOETOIDEI
  Family HEMIRAMPHIDAE
      25. *Hemiramphus limbatus* (Cuv. & Val.)   . .   "Morashu"
      26. *Hemiramphus cantori* Bleeker   . .   "Morashu"
Order CYPRINODONTIFORMES
  Suborder CYPRINODONTOIDEI
    Family CYPRINODONTIDAE
      27. *Haplochilus lineatus* (Cuv. & Val.)
Order MUGILIFORMES
  Suborder MUGILOIDEI
    Family MUGILIDAE
      28. *Mugil cephalus* Linnaeus   . .   "Thirutha"
      29. *Mugil cunnesius* Cuv. & Val.   . .   "Kanambadu"
      30. *Mugil troscheli* Bleeker   .
      31. *Mugil parsia* Ham. Buch.
      32. *Mugil waigiensis* Quoy & Gaimard
      33. *Mugil poicilus* Day
      34. *Mugil belanak* Bleeker

35. *Mugil amarulus* Cuv. & Val. (?)

36. *Mugil seheli* (Forskal)

Order POLYNEMIFORMES

  Family POLYNEMIDAE

    37. *Eleutheronem tetradactylum* (Shaw)   ..   "Vaazhmeen"

    38. *Polynemus paradiseus* Linnaeus

Order PERCIFORMES

  Suborder PERCOIDEI

    Family CENTROPOMIDAE

      39. *Ambassis gymnocephalus* (Lacepede)

      40. *Ambassis urotaenia* Bleeker   ..   "Nandan"

      41. *Lates calcarifer* (Bloch)   ..   "Narimeen"

  Family SERRANIDAE

    42. *Serranus waandersi* (Day)

    43. *Serranus diacanthus* Cuv. & Val.

    44. *Serranus salmoides* (Lacepede)

  Family THERAPONIDAE

    45. *Therapon puta* Cuv. & Val.

  Family SILLAGINIDAE

    46. *Sillago sihama* (Forskal)

  Family CARANGIDAE

    47. *Caranx sansun* (Forskal)   ..   "Vatta"

    48. *Chorinemus toloo* Cuv. & Val.

    49. *Chorinemus moadetta* Cuv. & Val.   ..   "Pannachi"

    50. *Trachynotus ovatus* (Linnaeus) OR
        Trachinotus blochii (Lacepede)

  Family LUTIANIDAE

    51. *Lutianus argentimaculatus* (Forskal)   ..   "Chemballi"

    52. *Lutianus johnii* (Bloch)

  Family LOBOTIDAE

    53. *Lobotes surinamensis* (Bloch)

  Family LEIOGNATHIDAE

    54. *Leiognathus equulus* (Forskal)   ..   "Kavari"

    55. *Leiognathus brevirostris* (Val.)

    56. *Leiognathus lineolatus* (Val.)

    57. *Leiognathus fasciatus* (Lacepede)

    58. *Secutor ruconius* (Hamilton) OR
      Equula ruconius (Hamilton)

59. *Secutor insidiator* (Bloch) OR
    Equula insidiatrix Bloch
60. *Gerres filamentosus* Cuv. & Val.   .. "Prānjil"
61. *Gerres lucidus* Cuv. & Val.
62. *Gerres oblongus* Cuv. & Val.

Family POMADASYIDAE
63. *Pristipoma hasta* (Bloch)
64. *Pristipoma operculare* Playfair
65. *Pritipoma guoraka* (Russell)

Family SCIAENIDAE
66. *Sciaena albida* (Day)
67. *Sciaena glaucus* Day
68. *Sciaena axillaris* (Cuv. & Val.)
69. *Sciaena coiter* (Hamilton)
70. *Sciaena carutta* (Bloch) (?)
71. *Pama pama* (Hamilton)
72. *Sciaenoides biauritus* (Cantor)

Family LETHRINIDAE
73. *Lethrinus reticulatus* Cuv. & Val.

Family SPARIDAE
74. *Chrysophrys berda* (Forskal)

Family DREPANIDAE
75. *Drepane punctata* (Linnaeus)   .. "Pundthu"
Family SCATOPHAGIDAE
76. *Scatophagus argus* (Bloch)   .. "Nachcha Karimeen"

Family CICHLIDAE
77. *Etroplus suratensis* (Bloch)   .. "Karimeen"
78. *Etroplus maculatus* (Bloch)   .. "Pallathi"

Suborder SIGANOIDEI
Family SIGANIDAE (TEUTHIDAE)
79. *Teuthis margaritifera* Gunther
80. *Teuthis sutor* Gunther

Suborder GOBIOIDEI
Family GOBIIDAE
81. *Trypauchen vagina* Bloch & Schneider
82. *Gobioides caeculus* (Bloch & Schneider)
83. *Glossogobius giuris* (Hamilton)   .. "Pootan"

Suborder COTTOIDEI
Family PLATYCEPHALIDAE
84. *Platycephalus insidiator* (Forskal)

Order PLEURONECTIFORMES
Suborder PLEURONECTOIDEI
Family SOLEIDAE
85. *Synaptura orientalis* (Bloch & Schneider)

Family CYNOGLOSSIDAE
86. *Cynoglossus bengalensis* (Bleeker)
87. *Cynoglossus punticeps* (Richards)
88. *Cynoglossus lingua* Hamilton

Order TETRODONTIFORMES
Suborder BALISTOIDEI
Family TRIACANTHIDAE
89. *Triacanthus brevirostris* Temminck & Schlegel   .. "Chapperi"

Suborder TETRODONTOIDEI
Family TETRODONTIDAE
90. *Tetrodon patoca* Hamilton

Order BATRACHOIDIFORMES
Family BATRACHOIDIDAE (BATRACHIDAE)
91. *Batrachus grunniens* (Linnaeus)   .. "Thavalemeen"

PRAWNS

Family PALAEMONIDAE
92. *Palaemon carcinus* Fabricius

Family PENAEIDAE
93. *Penaeus indicus* (M.—Edw.)
94. *Penaeus carinatus* Dana
95. *Metapenaeus dobsoni* Miers   .. "Kadal Konje"
96. *Metapenaeus monoceros* Fabricius
97. *Metapenaeus affinis* (M.—Edw.)
98. *Parapenaeopsis stylifera* (M.—Edw.)

Family SERGESTIDAE
99. *Acetes erythraeus* Nobili (?)

CRABS

Family PORTUNIDAE
100. *Scylla serrata* (Forskal)
101. *Neptunus (Neptunus) sanguinolentus* (Herbst)
102. *Neptunus (Neptunus) pelagicus* (Linnaeus)

[130]

ACHIASMAL ASSOCIATION OF HOMOLOGOUS CHROMOSOMES IN THE MALE MEIOSIS OF *HALYS DENTATUS* (HETEROPTERA)

By

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Introduction

The object of this communication is to report certain interesting features in the spermatogenesis of the bug, *Halys dentatus*, which escaped the notice of the previous investigator of this material, Dr. G. K. Manna, who published an exceedingly brief account of it (1951). These features, which have a bearing on our ideas of the role of chiasmata in maintaining the integrity of bivalents at the first metaphase (Darlington, 1937), are considered too important to be ignored, and so a brief account of the entire course of meiosis of this bug is given below with special reference to the unusual features referred to above.

Material and Methods

Specimens of *Halys dentatus* were collected from groves of Allahabad and sacrificed immediately on being brought to the laboratory. Testes, which are compact, kidney-shaped structures, deeply purple in colour, were fixed in Sanfelice's fluid and sections were cut at 12μ. Staining was carried out with iron-haeamatoxyline, gentian violet, and Feulgen's dye. All the diagrams have been made with camera lucida and drawn to the magnification indicated below the figures. For the reason that appears below, all the diagrams have been drawn from fixed and stained material alone and not from acetocarmine squash preparations.

Observations

Spermatogonial mitosis. Fourteen chromosomes occur on the spermatogonial metaphase plate, which fall into six pairs and two unpaired elements, of which one is the smallest element of the entire complement, and the other nearly equals in size the members of a pair which rank smallest in length apart from the small unpaired element (Fig. 1). Of the unpaired chromosomes, the smallest is labelled Y-chromosome by Manna and the somewhat larger element, the X-chromosome, although he did not examine the female chromosome complement. I have however, studied the ovarian cells of *H. dentatus* and find that the smallest element is unrepresented in the female chromosome complement, while the element some-what bigger than this, is represented by two chromosomes. Manna's lebelling of sex chromosomes, though done without proper examination, thus turns out to be correct. Study of the metaphase plate in side view reveals the fact that, as usual in bugs, chromosomal fibres are attached to the chromosomes all along their length, which faces the poles.

Anaphasic separation of daughter-chromosomes and their poleward movements are normal.

[131]

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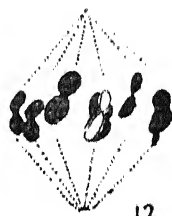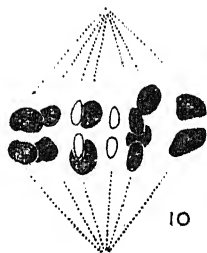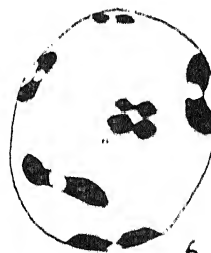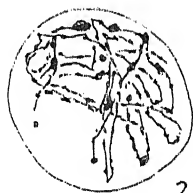
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Figs. 1, 9-12 are drawn from Sanfelice, gentian-violet preparations, while figs. 2, 8 are drawn from Sanfelice iron-haematoxyline preparations.

Fig. 1.   Spermatogonial metaphase showing 6 pairs of autosomes and 2 sex chromosomes (outlined) the smaller of the two being Y- and the larger, the X- chromosome.

Fig. 2.   Leptotene nucleus.

Fig. 3.   Zygotene nucleus.

Fig. 4.   Diplotene nucleus ; the sex chromosomes form a single heteropyenotic mass.

Figs. 5-8. Diakinetic nuclei, in all of which the Y- chromosome has divided into 2 chromatids, which have moved away from each other.

Fig 5.   In case of two autosomal bivalents, the paired chromosomes have separated away completely, while in case of another two autosomal bivalents, the paired chromosomes are terminally inter-connected by a very thin thread. The X- chromosome adheres to the nuclear membrane at 9 o'clock in the figure. In addition to these, there is a single dissociated chromosome, the partner of which is not included in the section. A bivalent is missing.

Fig. 6.   Shows three pairs of homologous chromosomes, completely separated from each other, and one bivalent in which the separation of the paired chromosomes is almost complete. Two bivalents in the centre remain intact. The X- chromosome is probably left out of the section.

Fig. 7.   Shows a pair of completely separated homologous chromosomes, located far away from each other, and a pair of incompletely separated ones. In the centre there is a bivalent which has the paired elements connected terminally by a pair of fine threads. In addition to these, there are two bivalents which are intact and a single chromosome (at 11 o'clock) the partner of which is not included in the section, or it may be undivided X- chromosome.

Fig. 8.   Shows three pairs of completely dissociated homologous autosomes, two bivalents in which the degree of separation is not clearly observable and one intact bivalent. The X- chromosome is probably missing, or the chromosomes at the bottom may be the daughter X- chromosomes, in which case an autosomal bivalent is missing.

Fig. 9.   1st.metaphase in polar view, showing 6 bivalents and the centrally placed X- and Y- chromosome (outlined).

Fig. 10.   Early first anaphase in side view. The X- and Y- chromosome have each divided into two.

Fig. 11.   Second metaphase in polar view, showing 6 autosomes and a centrally placed sex pseudo-bivalent.

Fig. 12.   Second metaphase in side view, showing six chromosomes and the sex pseudo-bivalent at the equator of the spindle.

Meiosis. The leptotene threads are fine, beaded threads, disposed throughout the nucleus at random, though in some nuclei a tendency towards polarization is observed (fig. 2). At zygotene, synapsis is normal and complete for all autosome pairs, and as far as can be made out, involves the pairing of homologous chromosomes (fig. 3). Bouquet is observed in a small proportion of nuclei. At diplotene each bivalent bears loops separated by points of contact (fig. 4). Some of these, it seems reasonable to assume, are chiasmata, although the four chromatids composing each bivalent at this stage, cannot be made out clearly and their interconnections are difficult of observation and remain obscure in most cases. However, a few favourable nuclei are observed of which detailed examination can be made. The diplotene stage is of a short-lived duration, as is indicated by the scarcity of diplotene nuclei, and the confused stage sets in soon after its onset. Its onset is heralded well before it actually sets in, for the pachytene threads stain pronouncedly more feebly than the early zygotene ones and during the short-lived diplotene the capacity of the bivalents to take stain is lowered still further. During the confused stage, as usual, the bivalents are reduced to amorphous, non-staining bits and masses of material. The sex chromosomes, which are present throughout the prophase as a single, or, rarely, two, condensed, deeply-stained masses, stand out in sharp contrast to the autosomes, as a deeply-stained, single disc, but quite often as two separate discs. The confused stage lasts for a comparatively long duration, and on its close the diakinesis gets under way (figs. 5–9). The diakinetic nuclei present features of striking interest. Even a cursory examination reveals at once the unexpected fact that the chromosomal elements number more than the expected seven or eight bodies—depending on whether the X- and Y- chromosome are associated into one mass or occur as separate bodies. The reason for this is quite apparent too. The Y- chromosome, which can be identified readily on account of its notably small size, has divided into two elements, which often lie apart from each other (figs. 5-8). It is not so easy to identify the X–chromosome at this stage, but its identity may sometimes be reasonably surmised by its size. Like the Y- chromosome, the X-chromosome, may also be found divided into two elements. But this is not all. Some autosomal bivalents are found dissociated, completely or incompletely, into two chromosomes, by resolution of the chiasmata (figs. 5-8). The associated (and most probably chiasmally interconnected) autosomes, forming a bivalent, appear to be driven apart, possibly by forces of repulsion arising from their entire surfaces, and their terminal connections are drawn into exceedingly thin strands, which are ultimately broken, setting the partner chromosomes free of each other. One cannot reasonably assume that this is the fate of any particular autosomal bivalent, as on account of the largeness of the nuclei at this stage, their entire chromosomal contents are not found contained in them, one or two elements being missing, Acetocarmine squash material may be considered suspect on account of the danger of accidental stretching apart of the paired chromosomes at diakinesis and so has not been used as a basis for these observations. However, in most of the diakinetic nuclei, some of the autosomal bivalents are found dissociated. The products of the dissociation of any one bivalent can be usually identified with some certainty on the ground of the similarity of their size, shape and disposition. Examination of a sufficiently large number of diakinetic nuclei convinces one that in all probability some bivalent is disintegrated in most nuclei.

The late diakinesis or pro-metaphase is apparently very short-lived, and the first metaphase gets under way quickly, so that the details of the reassociation of the separated homologous chromosomes escape observation. However,

at all the first metaphases examined, all the homologous chromosomes are fully and completely associated to give rise to normal-looking bivalents (figs. 9 and 10). It is apparent that this is, at least for some of the bivalents, an association of condensed chromosomes, not comparable to the orderly length-wise pairing of the zygotene threads, and that formation of fresh chiasmata is certainly out of the question at this stage. The pairing of the homologous chromosomes is, therefore, maintained at the first metaphase by special forces of attraction emanating from them. The X- and Y- daughter-chromosomes come together, forming single sex-chromosomes, and are, in all cases, orientated separately on the metaphase spindle. At the first anaphase the paired autosomes move towards the opposite poles and along with these go the separated X- and Y- daughter-chromosomes. Each Ist anaphase pole, thus, receives eight chromosomes, six autosomes and two sex-chromosomes. At the second metaphase seven chromosomal elements are orientated on the equator of the spindle, six autosomes and a pseudo-bivalent formed of X- and Y- chromosome (fig. 11), which are dissociated immediately after coming in touch and remain situated apart from each other towards the opposite poles (fig. 12). The autosomes, as usual, divide each into two, and the daughter-chromosomes move to the opposite poles, the X- or Y- chromosome passing along with them. At the end of the second anaphase each centre contains six autosomes and one of the two sex-chromosomes. In the early spermatid nuclei the individual chromosome can be counted for some time.

The course of meiosis runs normally in each lobe of the testis. There is no harlequin lobe (Schrader 1945 *a*, *b*, 1946, *a*, *b*; Srivastava, 1957).

Discussion

The principal feature of interest marking the spermatogenesis of this bug is the complete dissociation of some paired autosomes during diakinesis and their re-association towards the end of this phase, resulting in the appearance of normal-looking bivalents at the first metaphase. These bivalents are fully condensed and normally orientated. It is obvious that the integrity of these is not maintained by chiasmal interconnexions, which are absent, but by the operation of special forces of attraction.

Several instances of achiasmal association of chromosomes are known, the most notable reports being (apart from the male Diptera) those concerning meiosis in scorpions, where it seems to be the rule rather than the exception (Piza, 1939, 1940, 1943; reference in Srivastava and Agrawal, 1961). One striking difference between these instances of principally the same phenomenon, is that, in the scorpions, (for example, in *Palamnaeus longimanus* studied by Srivastava and Agrawal, 1961) the homologous chromosomes show distance pairing from the beginning of the first prophase down to the end of the first metaphase, as if the integrity of the bivalent is maintained by the simultaneous operation of forces of attraction and repulsion, the distance pairing representing an equilibrium position. In *Halys dentatus* the association of autosomes at the first metaphase is very close indeed and the two individul elements of a pair cannot be distinguished from each other at all, in contrast to the situation in *Palamnaeus longimanus*, where the members of a pair remain visibly separate from each other at the full first metaphase. It seems reasonable to assume that in *Halys dentatus* forces of attraction alone are in play at the first metaphase.

The X- and Y- chromosome manifest the usual property of being out of step with the euchromatic elements in the cycle of spiralization and despiralization, being deeply condensed in the meiotic prophase, especially so in the

confused stage. The coming together of the daughter X- and Y- chromosome, at metaphase, however, may not be ascribable to the unspecific attraction exercised by heterochromation, for in that case one would expect the association of X- and Y- chromosome at metaphase about as frequently as X- to X- and Y- to Y- chromosome taken together. This never happens. In about twenty-five Ist metaphase plates examined no instance of an association of X- and Y- element has been found. So it might be thought that the association of daughter X- and Y- chromosomes is brought about by the same type of specific attraction as operates between homologous autosomes. However, two considerations might be thought to weigh against this conclusion. For one thing, at the Ist metaphase, in most Heteroptera, X- and Y- chromosome do not pair at all (or only for a very short time). The forces responsible for keeping X- and Y- chromosome apart from each other can be reasonably supposed to prevent the association of daughter sex chromosomes. Secondly, many more plates should have been studied for this purpose than has been actually done, for there are obvious chances of misobservation.

These observations indicate the dispensability of chiasmata as a mechanical force holding the paired chromosomes intact at the first metaphase. However, the universality of the prevalence of chiasmata indicates their importance, both genetical and mechanical, and their dispensability in some organisms or groups of organisms is to be considered exceptional, associated with evolution of peculiar devices to take their place—special attraction forces and such-like factors.

The phenomenon of the disintegration of the autosomal bivalents may be considered an extreme form of prometaphase stretch (White, 1954).

Summary

1. The diploid chromosome complement of *Halys dentatus* consists of six pairs of autosomes and an X- and a Y- chromosome.

2. Synapsis and formation of chiasmata occur normally, but at diakinesis some of the paired autosomes separate away from their partners on account of the resolution of the chiasmata. The Y- and probably X- chromosome also divides into two elements each, the daughter sex chromosomes being separated away from each other completely.

3. At the first metaphase, the disassociated homologous autosomes come together again and give rise to normal-looking bivalents. Similarly, the daughter X- chromosomes and the daughter Y- chromosomes become closely reassociated to appear as single elements.

4. At the first anaphase each autosome separates away from its partner and each sex chromosome divides into two.

5. At the second metaphase the X- and Y- chromosome show 'touch-and-go' pairing and form a pseudo-bivalent, eventually moving to the opposite poles along with the daughter-autosomes formed by the division of each autosome.

6. There is no harlequin lobe in the testes of this bug.

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SHAPE ANALYSIS OF QUARTZ GRAINS OF GREEN SANDSTONES CHHUI HILLS, JABALPUR, MADHYA PRADESH

By

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Introduction

The Green sandstones of Lameta series of Cretaceous age is met with in a beautiful section in Chhui Hills, Jabalpur, overlying the Jabalpur and overlain by the traps.

As the name suggests the green sandstones are green in colour. These are loosely cemented and poorly compacted.

This paper relates with the shape analysis of the quartz grains of Green sandstones. The object of the study is,—

(i) to trace the trend of variation in sphericity and roundness of the sediments from coarser to finer grades of sizes, and

(ii) to investigate the sediment characteristics dependent upon these variables.

Materials and Methods

The disaggregated sediments of the Green sandstones were mechanically analysed through a set of B. S. Sieves. Thus fractioned products were labelled as below :

Sample Number	Product
I	$-14+18$ Mesh (B.S.S.)
II	$-18+25$,, ,,
III	$-25+52$,, ,,
IV	$-52+72$,, ,,
V	$-72+100$,, ,,
VI	$-100+150$,, ,,
VII	$-150+170$,, ,,
VIII	$-170+200$,, ,,

A representative portion of the sands from each product was separately mounted on glass slides, and the camera lucida sketches were drawn on paper. After usual estimation of large number of sediments the sphericity and roundness numbers of some of the representative grains of the samples were determined according to the methods described by Wadell (1935). The radii of the corners of the grains and that of the smallest circumscribing and largest inscribing circles were obtained with the help of a circular scale ; the area of the grain projection was obtained with the help of a planimeter.

Definitions

Some formulae which are used here, have been defined below :

Sphericity, ψ is given by

$$\psi = \frac{dc}{Dc}$$

where dc=diameter of a circle equal in area to the grain projection.

Dc=diameter of the smallest circle circumscribing the projection.

The arithmetic mean sphericity is obtained by the expression

$$\bar{\psi} = \frac{1}{n} \Sigma \psi$$

where $\bar{\psi}$ = mean sphericity

and n = number of observations

However, with the same mean value, the sphericity distribution may be different for the variates. Thus the mean deviation, d, which is the mean of the deviations of the observations from their means, is given by

$$d = \frac{1}{n} \Sigma \mid \psi - \bar{\psi} \mid$$

To obtain the measure of dispersion the standard deviation σ_ψ is obtained by the equation

$$\sigma_\psi = \sqrt{\frac{1}{n} \Sigma(\psi - \psi)^2}$$

The coefficient of shape sorting (Krumbein and Sloss, 1951) S_ψ may be obtained by the formula

$$S_\psi = \sqrt{\frac{Q_3}{Q_1}}$$

where Q_1=first quartile

and Q_3=third quartile

The skewness S_k, is calculated from the expression

$$S_k = \frac{Q_1 + Q_3 - 2Q_2}{Q_3 - Q_1}$$

where Q_2 denotes the second quartile

Shaping factor (Verma, 1958) has been determined from the equation

$$S. F. = 1 - \frac{d\psi}{\bar{\psi}}$$

The roundness number P is defined as

$$P = \frac{\Sigma r}{R} / N$$

where Σr = sum of the radii of the corners

R = radius of the maximum inscribed circle, and

N = number of corners

The mean roundness $\overline{P}$, is given by

$$\overline{P} = \frac{1}{n} \Sigma P$$

As in the case of sphericity the distribution of roundness may be different for the variates, and the mean deviation, d, is calculated from the expression

$$d = \frac{1}{n} \Sigma \mid P - \overline{P} \mid$$

where $\mid P - P \mid$ = deviation of the observation from the mean. To have an idea of measure of dispersion of roundness, the standard deviation can be calculated similarly as in the case of sphericity. The equation to be used in this case will be

$$\sigma_P = \sqrt{\frac{1}{n} \Sigma (P - \overline{P})^2}$$

The degree of variation in roundness may be obtained by the equation

$$S_P = \sqrt{\frac{Q_3}{Q_1}}$$

where S_P = degree of variation in roundness

Q_1 = first quartile

and Q_3 = third quartile

The skewness, S_k, is obtained from

$$S_k = \frac{Q_1 + Q_3 - Q_2}{Q_3 - Q_1}$$

where Q_2 is the second quartile

Rounding factor has been calculated from

$$R.F. = 1 - \frac{dP}{\overline{P}}$$

Sphericity

The sphericity numbers of some of the representative grains of the eight samples are recorded in Table I.

TABLE I

Values of ψ, $(\psi - \overline{\psi})$ and $(\psi - \overline{\psi})^2$

Grain	Sphericity ψ	$(\psi - \overline{\psi})$	$(\psi - \overline{\psi})^2$	Grain	Sphericity ψ	$(\psi - \dot{\psi})$	$(\psi - \overline{\overline{\psi}})^2$
			SAMPLE I				
A	0·79	− 0·02	0·0004	K	0·78	− 0·03	0·0009
B	0·82	+0·01	0·0001	L	0·73	− 0·08	0·0064
C	0·80	− 0·01	0·0001	M	0·82	+0·01	0·0001
D	0·85	+0·04	0·0016	N	0·85	+0·04	0·0016
E	0·79	− 0·02	0·0004	O	0·76	− 0·05	0·0025
F	0·82	+0·01	0·0001	P	0·85	+0·04	0·0016
G	0·88	+0·07	0·0049	Q	0·78	− 0·03	0·0009
H	0·88	+0·07	0·0049	R	0·81	0·00	0·0000
I	0·86	+0·05	0·0025	S	0·77	− 0·04	0·0016
J	0·84	+0·03	0·0009	T	0·73	− 0·08	0·0064
			SAMPLE II				
A	0·82	− 0·01	0·0001	K	0·66	− 0·15	0·0225
B	0·73	− 0·08	0·0064	L	0·85	+0·04	0·0016
C	0·77	− 0·04	0·0016	M	0·79	− 0·02	0·0004
D	0·91	+0·10	0·0000	N	0·89	− 0·08	0·0064
E	0·82	+0·01	0·0001	O	0·82	+0·01	0·0001
F	0·92	+0·11	0·0121	P	0·73	− 0·08	0·0064
G	0·82	+0·01	0·0001	Q	0·89	+0·08	0·0064
H	0·77	− 0·04	0·0016	R	0·75	− 0·06	0·0036
I	0·82	+0·01	0·0001	S	0·77	− 0·04	0·0016
J	0·74	− 0·07	0·0049	T	0·88	+0·07	0·0049
			SAMPLE III				
A	0·88	+0·06	0·0036	K	0·93	+0·11	0·0121
B	0·75	− 0·07	0·0049	L	0·96	+0·14	0·0196
C	0·81	− 0·01	0·0001	M	0·94	+0·12	0·0144
D	0·77	− 0·05	0·0025	N	0·79	− 0·03	0·0009
E	0·85	+0·03	0·0009	O	0·77	− 0·05	0·0025
F	0·88	+0·06	0·0036	P	0·77	− 0·05	0·0025
G	0·77	− 0·05	0·0025	Q	0·79	− 0·03	0·0009
H	0·87	+0·05	0·0025	R	0·79	− 0·03	0·0009
I	0·82	− 0·00	0·0000	S	0·70	− 0·12	0·0144
J	0·81	− 0·01	0·0001	T	0·87	+0·05	0·0025

Grain	Sphericity ψ	$(\psi - \overline{\psi})$	$(\psi - \overline{\psi})^2$	Grain	Sphericity ψ	$(\psi - \overline{\psi})$	$(\psi - \overline{\psi})^2$
			SAMPLE IV				
A	0·76	− 0·02	0·0004	K	0·81	+0·03	0·0009
B	0·89	+0·11	0·0121	L	0·70	− 0·08	0·0064
C	0·81	+0·03	0·0009	M	0·72	− 0·06	0·0036
D	0·66	− 0·12	0·0144	N	0·82	+ 0·04	0·0016
E	0·89	+0·11	0·0121	O	0·78	0·00	0·0000
F	0·91	+0·13	0·0169	P	0·76	− 0·02	0·0004
G	0·78	0·00	0·0000	Q	0·84	+0·06	0·0036
H	0·68	− 0·10	0·0100	R	0·60	− 0·18	0·0324
I	0·69	− 0·09	0·0081	S	0·81	+0·03	0·0009
J	0·91	+0·13	0·0169	T	0·76	− 0·02	0·0004
			SAMPLE V				
A	0·72	− 0·05	0·0025	K	0·74	− 0·03	0·0009
B	0·66	− 0·11	0·0121	L	0·79	+0·02	0·0004
C	0·70	− 0·07	0·0049	M	0·73	− 0·04	0·0016
D	0·72	− 0·05	00·025	N	0·89	+0·12	0·0144
E	0·82	+0·05	0·0025	O	0·82	+0·05	0·0025
F	0·81	+0·04	0·0016	P	0·86	+0·09	0·0081
G	0·69	− 0·08	0·0064	Q	0·91	+0·14	0·0196
H	0·75	− 0·02	0·0004	R	0·72	− 0·03	0·0009
I	0·67	− 0·10	0·0100	S	0·83	+0·06	0·0036
J	0·77	0·00	0·0000	T	0·89	+0·12	0·0144
			SAMPLE VI				
A	0·82	+0·04	0·0016	K	0·78	0·00	0·0000
B	0·88	+0·10	0·0100	L	0·74	− 0·04	0·0016
C	0·71	− 0·07	0·0049	M	0·80	+0·02	0·0004
D	0·67	− 0·11	0·0121	N	0·71	− 0·07	0·0049
E	0·66	− 0·12	0·0144	O	0·76	− 0·02	0·0004
F	0·66	+0·12	0·0144	P	0·91	+0·13	0·0169
G	0·93	+0·15	0·0225	Q	0·84	+0·06	0·0036
H	0·87	+0·09	0·0081	R	0·76	− 0·02	0·0004
I	0·57	+0·21	0·0441	S	0·89	+0·11	0·0121
J	0·85	+0·07	0·0049	T	0·87	+0·09	0·0081

Grain	Sphericity ψ	$(\psi - \bar{\psi})$	$(\psi - \bar{\psi})^2$	Grain	Sphericity ψ	$(\psi - \bar{\psi})$	$(\psi - \bar{\psi})^2$
			SAMPLE VII				
A	0·84	+0·08	0·0064	K	0·86	+0·10	0·0100
B	0·79	+0·03	0·0009	L	0·44	− 0·32	0·1024
C	0·85	+0·09	0·0081	M	0·76	0·00	0·0000
D	0·91	+0·15	0·0225	N	0·70	− 0·06	0·0036
E	0·76	0·00	0·0000	O	0·70	− 0·06	0·0036
F	0·98	+0·22	0·0484	P	0·64	− 0·12	0·0144
G	0·82	+0·06	0·0036	Q	0·71	− 0·05	0·0025
H	0·76	0·00	0·0000	R	0·73	+0·03	0·0009
I	0·89	+0·13	0·0169	S	0·67	− 0·09	0·0081
J	0·88	+0·12	0·0144	T	0·47	− 0·29	0·0841
			SAMPLE VIII				
A	0·82	+0·06	0·0036	K	0·84	+0·08	0·0064
B	0·54	− 0·22	0·0484	L	0·74	− 0·02	0·0004
C	0·74	− 0·02	0·0004	M	0·69	− 0·07	0·0049
D	0·80	+0·04	0·0016	N	0·74	− 0·02	0·0004
E	0·66	− 0·10	0·0100	O	0·74	− 0·02	0·0004
F	0·60	− 0·15	0·0256	P	0·98	+0·22	0·0484
G	0·67	− 0·09	0·0081	Q	0·78	+0·02	0·0004
H	0·67	− 0·09	0·0081	R	0·72	− 0·06	0·0036
I	0·95	+0·19	0·0361	S	0·86	+0·10	0·0100
J	0·84	+0·08	0·0064	T	0·80	+0·04	0·0016

From the above data, the mean sphericity and the mean and the standard deviations have been caluculated for the samples.

The frequencies for the various groups of sphericity numbers have been shown by histograms in figure 1. It may be seen that regular histograms are obtained upto sample III. Samples IV to VIII except sample V, show a break in the frequency distribution of sphericity numbers. In otherwords, the coarser fractions show continuity in the distribution of sphericity number and the finer fractions indicate ommission of some group or groups of sphericity numbers. The range of sphericity numbers in the case of latter is more, whereas the former range is more compact.

Cumulative frequency distribution curves have been obtained for the eight samples by plotting the cumulative frequency and percentage on the y-axis against the corresponding sphericity number on the x-axis. These plots are shown in figure 2. From these curves, the values of the quartiles have been obtained and the coefficient of shape sorting calculated thereform. Some important statistical measures investigated, from the data given in Table I and from the cumulative curves shown in figure 2, have been tabulated below :
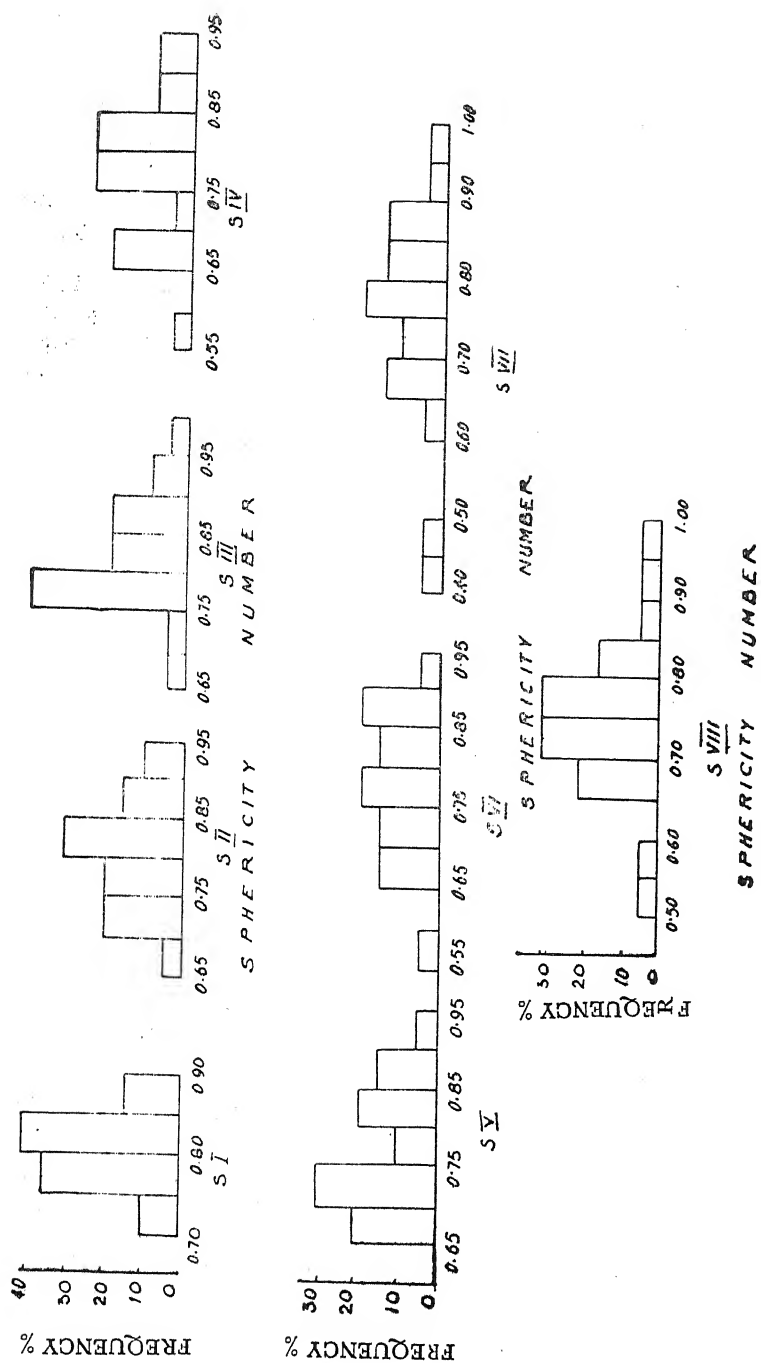
Fig. 1. Histograms showing the Frequency of the different measures of Sphericity

[S for Sample]

TABLE II
Some Statistical Parameters—Sphericity

Sample No. Parameter	I	II	III	IV	V	VI	VII	VIII
Range of Sphericity	0·73–0·88	0·66–0·92	0·70–0·96	0·60–0·91	0·67–0·91	0·57–0·93	0·44–0·98	0·54–0·98
Mean Sphericity	0·81	0·81	0·82	0·78	0·77	0·78	0·76	0·76
Mean deviation	0·036	0·055	0·056	0·068	0·063	0·082	0·10	0·085
Standard deviation	0·043	0·067	0·067	0 26	0·23	0·304	0·132	0·106
Median Sphericity	0·79	0·785	0·785	0·77	0·73	0·77	0·77	0·71
Coefficient of shape sorting	1·04	1·06	1·06	1·09	1·119	1·095	1·119	1·09
Skewness	− 0·20	− 0·10	+ 0·30	− 0·44	+ 0·21	+ 0·03	− 0·27	+ 0·31
Shaping factor	0·956	0·932	0·932	0·913	0·918	0·895	0·87	0·89
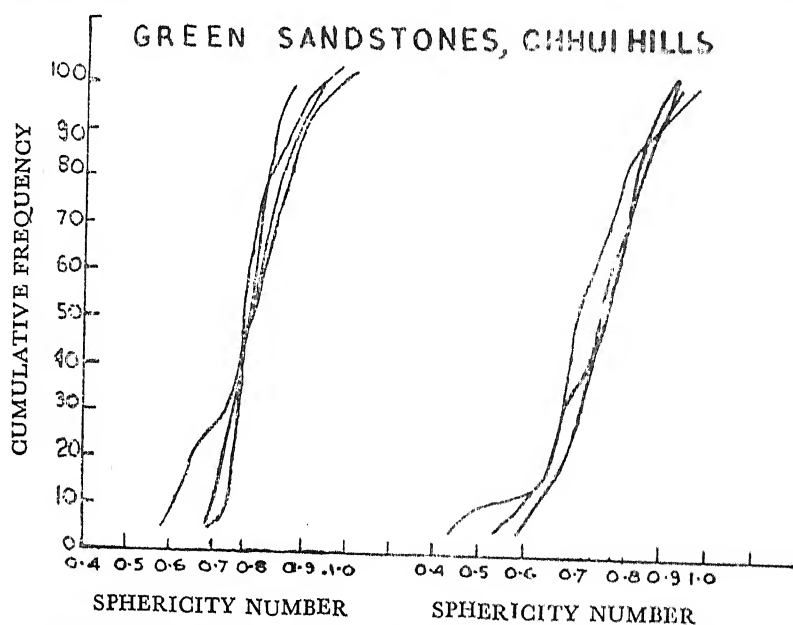
Fig. 2. Curves showing the cumulative frequency percentage vs sphericity number

The values of mean sphericity for the various samples indicate that the average sphericity numbers for sample I–III is between 0·81–0·28, and for samples III–VIII is between 0·76–0·78. This fall in values in fractions below 52 mesh (B. S. S.) again tends to show, as in the case of histograms, the dissimilarity between the coarser and finer fractions (with reference to 52 mesh). It is also observed that deviations are larger in the finer fractions, than in the coarser ones. This, perhaps indicates two loads, the coarser fraction representing one load and the finer comprising both the loads and hence greater deviation values in

them. Likewise coefficient of shape sorting, suggest a greater sorting with respect to sphericity in the coarser fractions, than in the finer ones. It may be further observed that the shaping factors for the coarser fractions indicate relatively larger degree of homogeneity. Sample IV–VIII, do not show any regular trend in the variation of shaping fractors with regard to size. The values increase as well as decrease with the decrease in size. Comparatively lower values of shaping factors in the finer fractions indicate that the degree of homogeneity in finer fractions is less.

It is interesting to note that mean sphericity is always higher than the median sphericity in these samples.

Roundness

The roundness numbers of some of the more representative grains of the eight samples are recorded in Table III.

TABLE III

Values of P, (P − P̄) *and* (P − P̄)²

Grain	Roundness P	(P − P̄)	(P − P̄)²	Grain	Roundness P	(P − P̄)	(P − P̄)²
			SAMPLE I				
A	0·44	+0·01	0·0001	K	0·42	− 0·01	0·0001
B	0·39	− 0·04	0·0016	L	0·61	+0·18	0·0324
C	0·43	− 0·00	0·0000	M	0·37	− 0·06	0·0036
D	0·45	+0·02	0·0004	N	0·62	+0·19	0·0361
E	0·22	− 0·21	0·0441	O	0·30	− 0·13	0·0169
F	0·66	+0·23	0·0529	P	0·45	+0·02	0·0004
G	0·64	+0·21	0·0441	Q	0·43	0·00	0·0000
H	0·26	− 0·17	0·0289	R	0·48	+0·05	0·0025
I	0·31	− 0·12	0·0144	S	0·43	0·00	0·0000
J	0·36	− 0·07	0·0049	T	0·35	− 0·08	0·0064
			SAMPLE II				
A	0·41	− 0·05	0·0025	K	0·44	− 0·02	0·0004
B	0·44	− 0·02	0·0004	L	0·61	+0·15	0·0225
C	0·52	+0·06	0·0036	M	0·27	− 0·19	0·0361
D	0·31	− 0·15	0·0225	N	0·46	0·00	0·0000
E	0·39	− 0·07	0·0049	O	0·66	− 0·20	0·0400
F	0·65	+0·19	0·0361	P	0·59	− 0·13	0·0169
G	0·46	0·00	0·0000	Q	0·39	− 0·07	0·0049
H	0·45	− 0·01	0·0001	R	0·38	− 0·08	0·0064
I	0·59	+0·13	0·0169	S	0·44	− 0·02	0·0004
J	0·46	0·00	0·0000	T	0·29	− 0·17	0·0289

Grain	Roundness P	$(P - \overline{P})$	$(P - \overline{P})^2$	Grain	Roundness P	$(P - \overline{P})$	$(P - \overline{P})^2$
			SAMPLE III				
A	0·45	− 0·06	0 0036	K	0·50	− 0·01	0·0001
B	0·51	0·00	0·0000	L	0·69	+0·18	0·0324
C	0·67	+0·16	0·0256	M	0·37	− 0·14	0·0196
D	0·55	+0·04	0·0016	N	0·51	0 00	0·0000
E	0·54	+0·03	0·0009	O	0·61	+0·10	0·0100
F	0·50	− 0·01	0·0001	P	0·44	− 0·07	0·0049
G	0·45	− 0·06	0·0036	Q	0·41	− 0·01	0 0100
H	0·66	+0·15	0·0225	R	0·52	+0·01	0·0001
I	0·68	+0·17	0·0289	S	0·59	+0 08	0·0064
J	0·31	− 0·20	0·0400	T	0·37	− 0·14	0·0196
			SAMPLE IV				
A	0·61	− 0·08	0·0064	K	0·92	+0·23	0·0529
B	0·71	+0·02	0·0004	L	0·73	+0·04	0·0016
C	0·86	+0·17	0·0289	M	0·57	+0·12	0·0144
D	0·66	− 0·03	0·0009	N	0·62	− 0·07	0·0049
E	0·31	− 0·38	0·1444	O	0·70	+0·01	0·0001
F	0·50	− 0·19	0·0361	P	0·63	− 0·06	0·0036
G	0·86	+0·17	0·0289	Q	0·62	− 0·07	0·0049
H	0·83	+0·14	0·0196	R	0·73	+0·04	0·0016
I	0·83	+0·14	0·0196	S	0·72	+0·03	0·0009
J	0·75	+0·06	0·0036	T	0·66	− 0·03	0·0009
			SAMPLE V				
A	0·60	+0·03	0·0009	K	0·88	+0·31	0·0961
B	0·53	− 0·04	0·0016	L	0·60	+0·03	0·0009
C	0·39	− 0·18	0·0324	M	0·60	+0·03	0·0009
D	0·61	+0·04	0·0016	N	0·56	− 0·01	0·0001
E	0·85	+0·28	0·0784	O	0 46	− 0·11	0·0121
F	0·47	− 0·10	0·0100	P	0·57	0 00	0·0000
G	0·52	− 0·05	0 0025	Q	0·41	− 0·16	0·0256
H	0·76	+0·19	0·0361	R	0·70	+0·13	0 0169
I	0 55	− 0·02	0·0004	S	0·42	− 0·15	0·0225
J	0·53	− 0·04	0·0016	T	0·40	− 0·17	0·0289

Grain	Roundness P	$(P-\bar{P})^2$	$(P-\bar{P})^2$	Grain	Roundness P	$(P-\bar{P})$	$(P-\bar{P})^2$
			SAMPLE VI				
A	0·50	− 0·11	0·0121	K	0·62	+0·01	0·0001
B	0·32	− 0·39	0·1521	L	0·83	+0·22	0·0484
C	0·40	− 0·21	0·0461	M	0·83	− 0·22	0·0484
D	0·79	+0·18	0·0324	N	0·52	− 0·09	0·0081
E	0·60	− 0·01	0·0001	O	0·43	− 0·18	0·0324
F	0·66	+0·06	0·0036	P	0·77	+0·16	0·0256
G	0·65	+0·04	0·0016	Q	0·80	+0·19	0·0361
H	0·80	+0·19	0·0361	R	0·75	+0·14	0·0196
I	0·59	− 0·02	0·0004	S	0·69	+0·08	0·0064
J	0·75	+0·14	0·0195	T	0·55	− 0·06	0·0036
			SAMPLE VII				
A	0·87	+0·19	0·0361	K	0·63	− 0·05	0·0025
B	0·85	+0·17	0·0289	L	0·66	− 0·02	0·0004
C	0·80	+0·12	0·0144	M	0·50	− 0·18	0·0324
D	0·56	− 0·12	0·0144	N	0·83	+0·15	0·0225
E	0·66	− 0·02	0·0004	O	0·66	− 0·02	0·0004
F	0·66	− 0·02	0·0064	P	0·80	+0·12	0·0144
G	0·46	− 0·22	0·0484	Q	0·77	+0·09	0·0081
H	0·50	− 0·18	0·0324	R	0·73	+0·05	0·0025
I	0·83	+0·15	0·0225	S	0·83	+0·15	0·0225
J	0·39	− 0·29	0·0841	T	0·61	− 0·07	0·0049
			SAMPLE VIII				
A	0·90	+0·18	0·0224	K	0·60	0·13	0·0169
B	0·83	+0·11	0·0121	L	0·75	+0·02	0·0004
C	0·73	0·00	0·0000	M	0·92	+0·19	0·0361
D	0·66	− 0·07	0·0049	N	0·75	+0·02	0·0004
E	0·73	0·00	0·0000	O	0·75	+0·02	0·0004
F	0·83	+0·10	0·0100	P	0·90	+0·17	0·0289
G	0·90	+0·17	0·0289	Q	0·66	− 0·07	0·0049
H	0·92	+0·19	0·0361	R	0·77	+0·04	0·0016
I	0·66	− 0·07	0·0049	S	0·50	− 0·23	0·0529
J	0·90	+0·17	0·0289	T	0·60	− 0·13	0·0169
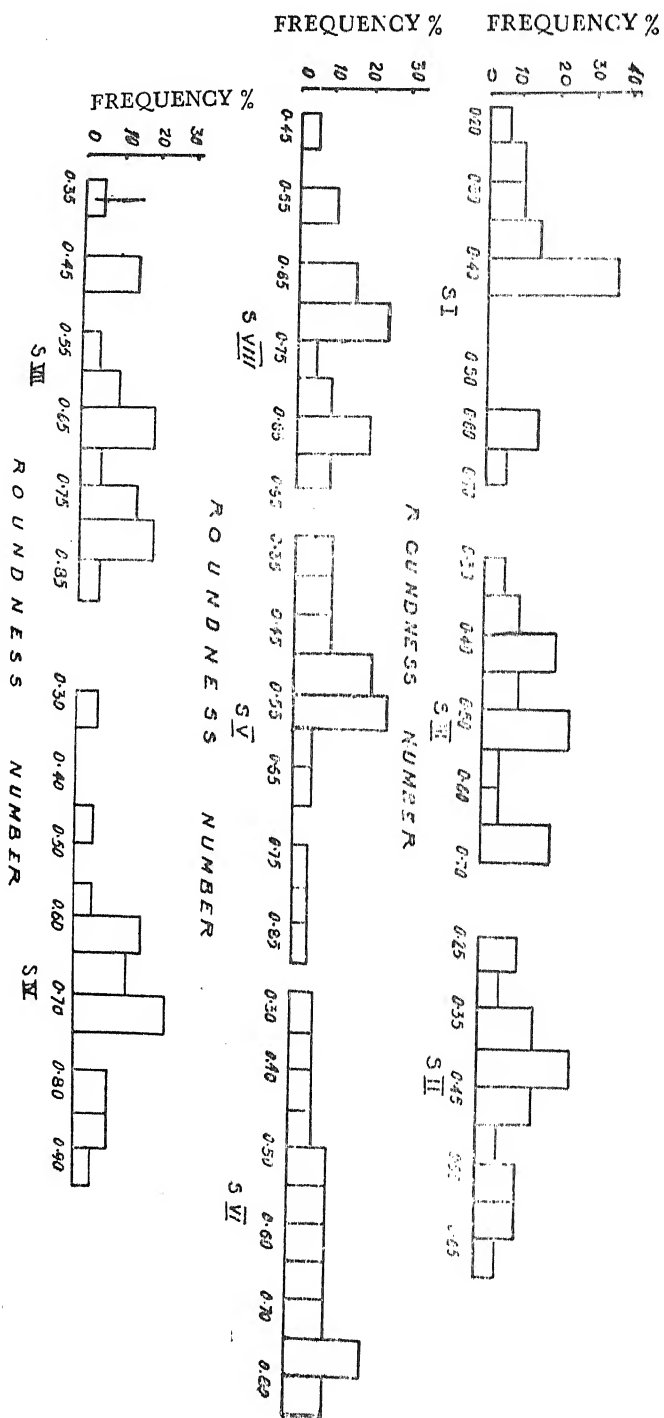
Fig. 3. Histograms showing the frequency of the different measures of Roundness

[S stands for Sample]

From the above data, the sediments constituting the Green sandstones may be classified into four roundness grades of Pettijohn (1957) as below :

TABLE IV

Classification—Roundness Grades of Pettijohn

Roundness Grade	Sample I	Sample II	Sample III	Sample IV	Sample V	Sample VI	Sample VII	Sample VIII
			PERCENTAGE					
0·21 to 0·25 Subangular	5·0	–	–	–	–	–	–	–
0·26 to 0·40 Subrounded	35·0	30·0	5·0	15·0	10·0	10·0	5·0	–
0·41 to 0·60 Rounded	40·0	55·0	10·0	60·0	65·0	30·0	20·0	15·0
0·60 Well rounded	20·0	15·0	85·0	25·0	25·0	60·0	75·0	85·0

The figures of the table indicates that the coarser sediments comprise essentially of subrounded to rounded grains, and the finer ones are made up of rounded to well rounded grains.

Mean roundness and the deviations—mean as well as standard, have been calculated from the data of Table III for the samples.
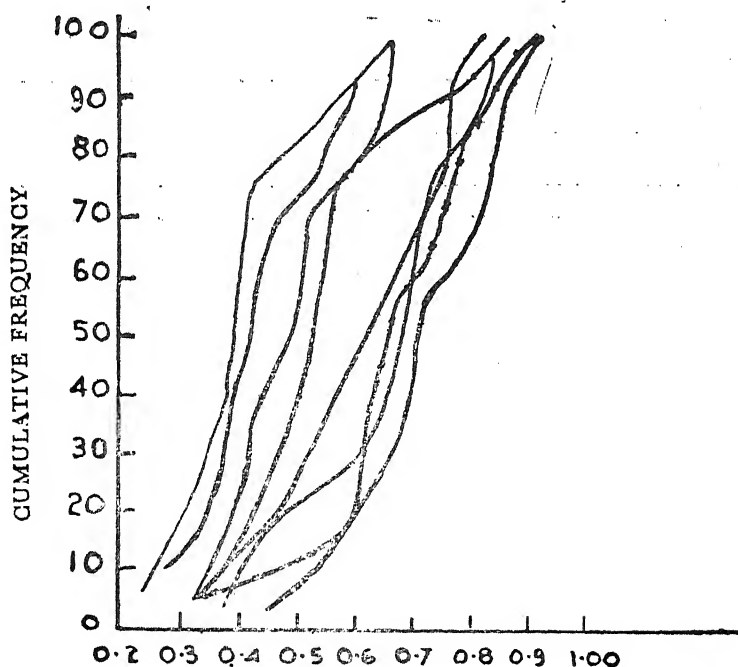
Fig. 4. Curves showing the cumulative frequency percentage vs roundness number.

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Histograms have been drawn, (Figure 3), showing the frequency of various groups of roundness numbers. A general study of the histograms tends to suggest a polymodal distribution of the roundness of the sediments, due to the presence secondary maxima. However, at least apparently two loads constitute the sediments—one coarser (upto sample III, +52 mesh B. S. S.) and the other finer (from sample IV onwards, – 52 mesh B. S. S. fractions). In the case of sediments of the former load, the roundness number do not have values higher than 0·69 whereas in the case of latter, the values on the higher side range upto 0·92. Similarly on the lower side, the roundness numbers go down upto 0·22 in the coarser fractions and it starts only from 0·31 in the finer groups.

Cumulative frequency distribution curves have been plotted (Figure 4) with cumulative frequency on the *y*-axis and the roundness number on the *x*-axis. From these curves, the values of the quartiles have been obtained. Some important statistical measures investigated from the data given in Table III and from the cummulative curves shown in figure 4, have been tabulated below :

TABLE V

Some Statistical Parameters—Roundness

Sample No. Parameters	I	II	III	IV	V	VI	VII	VIII
Range of Roundness Values	0·66–0·22	0·66–0·27	0·69–0·31	0·92–0·31	0·88–0·39	0·83–0·32	0·87–0·39	0·92–0·50
Mean Roundness	0·43	0·46	0·51	0·69	0·57	0·61	0·68	0·73
Mean deviation	0·090	0·085	0·085	0·104	0·103	0·135	0·111	0·104
Standard deviation	0·116	0·110	0·107	0·137	0·136	0·516	0·141	0·126
Coefficient of variation	26·9	23·9	47·6	19·8	23·8	81·7	20·4	14·2
Median Roundness	0·405	0·43	0·495	0·680	0·53	0·63	0·665	0·72
Degree of variation in roundness	1·14	1·19	1·19	1·09	1·13	1·22	1·16	1·14
Skewness	–0·5	+0·25	0	–0·16	+0·6	0	+0·15	+0·28
Rounding Factor	0·79	0·82	0·83	0·85	0·81	0·78	0·84	0·86

The mean roundness values of the grains in samples I to III lie within the range of "rounded" grade of Pettijohn's scale, whereas for those of sample IV-VIII lie in the "well rounded" grade, except in the case of sample V (the mean roundness in the latter case also is quite near the range for "well rounded" grains). Similarly, it has been observed that the values for deviations are rather high for samples IV-VIII and comparatively lower for sample I-III. The degree of variation in roundness is high in all the cases, indicating a high degree of sorting of grains with regard to roundness in each fraction.

As from the study of sphericity of these grains, roundness also suggests some sort of dissimilarity between the grains of the samples I-III with those of the samples IV-VIII.

The data given in table V do not show any regular pattern of variation in rounding factor. It may be seen that samples III and VI have a value "zero" for the skewness, suggesting that the symmetry is well balanced. Presence of

both clockwise and anticlockwise values of measures for skewness in other cases, indicates that the roundness numbers are not preferentially skewed on one side or the other.

It is rather interesting to note that the mean roundness is always higher than the median roundness in these sediments except in Sample VI.

GREEN SANDSTONE, CHHUI HILL
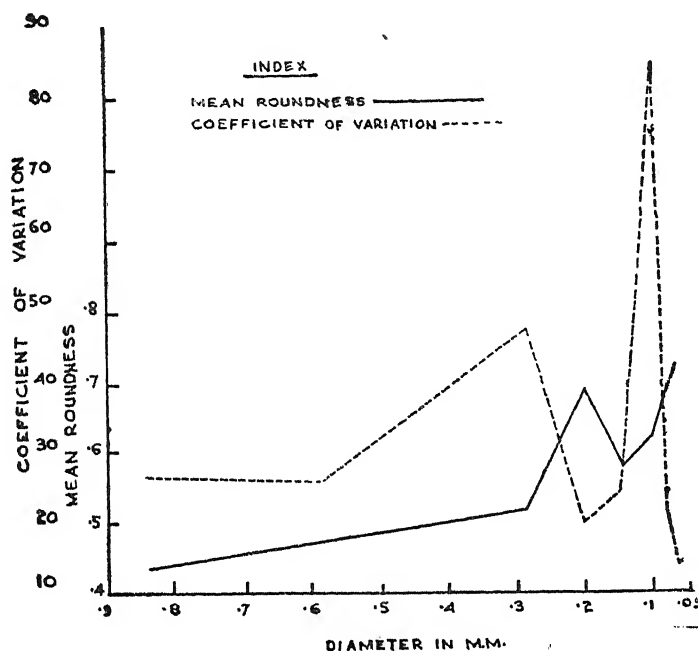
FIG. 5 SIZE ROUNDNESS RELATION SHIP

In figure 5 coefficient of variation and mean roundness have been plotted against the size of the sediments. There appears to be sympathetic behaviour of the coefficient of variation and mean roundness with the decrease in size of the particles upto 0·295 mm. The curves show same complex relationship afterwards by cutting each other at many places. This complexity may again be due to admixture of sediments of more than one type. The main load represented in the figure at the coarser side shows consistency due to sympathetic relationship between the variables and the variation in side.

Similar inference in favour of more than one load theory has been drawn from the study of scatter diagram of length and breadth/length of the grains as also from their mechanical analysis (results already communicated elsewhere for publication).
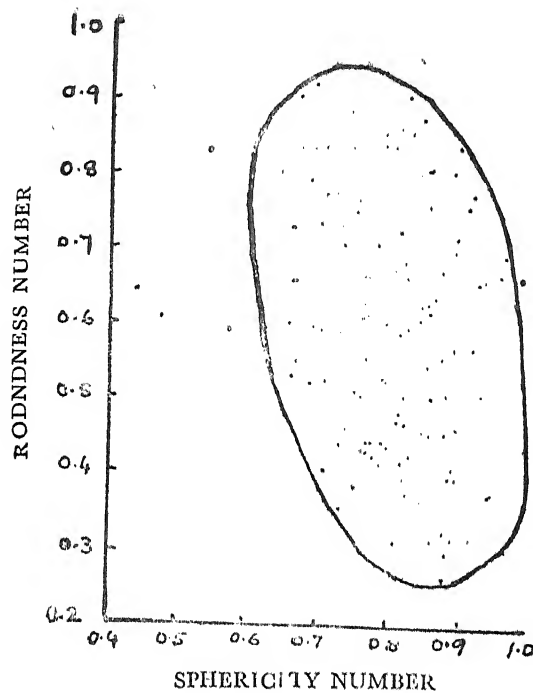
Fig. 6. Scatter diagram for Sphericity and Roundness.

Sphericity and Roundness

From the study of Table I and III, it is observed that for the same sphericity number there are different roundness number and *vice-versa*, indicating that no linear relationship exists between the two variables.   A scatter diagram (Figure 6) is prepared by plotting the sphericity numbers of the grains on x-axis and the corresponding roundness numbers on the y-axis.

From this diagram it is noted that the variables describe an ellipse (covering most of the plots except a few which lie outside)—a closed curve—with coordinates of the centre as 0·82, 0·59, semi-major axis $a = 0·36$ semi-minor axis, $b = 0·18$. The major axis of the ellipse is inclined at an angle of 75° with respect to x-axis. From these, the equation of the curve works out as

$$\frac{X^2}{(0·36)^2} + \frac{Y^2}{(0·18)^2} = 1$$

where $X = (x - 0·81) \cos 75° - (y - 0·60) \sin 75°$

and $Y = (x - 0·81) \sin 75° - (y - 0·60) \cos 75°$

This equation is characteristic of the sphericity—roundness distribution of these sediments.   The curve also indicates that the roundness values are more scattered and comparatively the sphericity number of the sediments are more compact.   The length of the major axis of the ellipse is double the length of the minor axis. The modal class for sphericity is 0·70–0·90 and for roundness 0·40–0·75. Maximum grains are covered in the area enclosed by the modal class.

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A comparison of Table II and V, yields some interesting conclusion—

(i) the roundness numbers have comparatively wider range of values than the sphericity numbers,

(ii) the values for mean sphericity are higher than the corresponding values of mean roundness,

(iii) the samples are more uniform with respect to sphericity than with respect to roundness as is indicated by the deviations and the shaping-rounding factors, and

(iv) samples I – III show more or less the same value for mean sphericity and fairly similar values for mean roundness. Both mean sphericity and mean roundness increase gradually upto +52 mesh (B. S. S.), represented by sample III. There is a conspicuous fall in the values for mean sphericity and rise in the values for mean roundness in the group of samples IV–VIII, but there is no regular pattern in the fall or rise in values. Taking the weight percentage it would appear that the fractions above 52 mesh (B. S. S.) form the main load and those below, constitute the secondary load of a river system. Thus the sediments are bimodal. This conclusion is further supported by some other factors of study such as mechanical analysis and the ratio of length and breadth of quartz grains.

Summary

Sphericity and roundness of quartz grains of Green sandstones of fresh water Lameta series (of Cretaceous age), Chhui Hills, Jabalpur (M. P.) have been determined. The average sphericity numbers for fractions coarser than 52 mesh (B. S. S.) vary between 0·81 and 82 and in the finer fractions it ranges from 0·76 to 0·78. Similarly the roundness values in the former groups of sediments range upto 0·69 whereas in the case of latter, it is found to be as high as 0·92. Coefficient of variation and the mean roundness have been plotted against the size. The graphs show sympathetic relations upto 0·295 mm and thereafter they cut each other at some places. This shows some complexity. Bimodal distributions is suggested for the sediments. An attempt to investigate a relation between sphericity and roundness has also been made.

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FLORAL ANATOMY OF ERYTHROXYLACEAE

By

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Introduction

Members of the family Erythroxylaceae have not received much attention from the point of view of floral anatomy. Recently Narayana (1960), studied the floral anatomy of three species of *Erythroxylum*. The present paper is on the floral morphology of *Aneulophus africanus* Benth., *Nectaropetalum kaessneri* Engl., *Erythroxy-lum novogratanense* (Morris) Hieron., *E. lanceum* Bojer, *E. pulchrum* A. St. Hil., and *E. suberosum* A. St. Hil.

Materials and Methods

The fixed materials of *Erythroxylum novogratanense* and *E. lanceum* were supplied by Dr. Anwari Dilmy. The rest of the species were studied from herbarium materials. Flowers and flower buds of *E. suberosum* and *E. pulchrum* were supplied by the Director, Botanical Gardens, Rio deJaneiro and *Nectaropetalum kaessneri* and *Aneulophus africanus* were obtained from the Director, Royal Botanical Gardens, Kew ; part of the material of the former taxon was supplied by Dr. Bernard Verd Court. Customary methods of processing, sectioning and staining were followed. The herbarium materials were processed according to the procedure described for *Durandea* (Narayana, 1964).

Flower

The flower is pedicellate, pentamerous (except in the gynoecium) penta-cyclic, regular, bisexual and hypogynous (Figs. 1, 12, 21, 29, 31–35, 39, 42, 43). The calyx in the various species of *Erythroxylum* is gamosepalous (Figs. 31, 34, 35) and polysepalous in the rest (Figs. 1, 5, 12, 20). The polypetalous corolla shows imbricate aestivation (Figs. 21, 42, 43). The petals in *Erythroxylum* species bear leafy appendages on the inner side (Fig. 42) and in *Nectaropetalum kaessneri* glands are found at their base. The androecium consisting of ten stamens is monadel-phous at the base (Figs. 8, 21, 35). The ovary consists of three carpels in *Aneulophus africanus* and *Erythroxylum* species (Figs. 8–10, 37–39, 42) and two in *Nectaropetalum kaessneri* (Figs. 21–26) with two ovules per locule in *Aneulophus africanus* (Figs. 9, 19) and one in *Nectaropetalum kaessneri* (Figs. 21, 23). In the various species of *Erythroxylum* two of carpels are sterile and their loculi which are ill developed, are vacant and the fertile carpel bears a solitary pendulous ovule (Figs 37–39, 42). In *E. suberosum* some of the flowers showed a tetracarpellary gynoecium (Figs. 40, 41). However, only one carpel is fertile and bears a solitary ovule (Figs. 40, 41). The loculi in *Aneulophus africanus* and *Erythroxylum* species are lined by an epidermal layer of thin walled, tangentially elongated cells with prominent nuclei and vacuolate cytoplasm (Figs. 10, 37, 38). The styles are free in *Aneulophus africanus* and *Erythroxylum* species (Figs. 1, 11, 29, 43) and the common style with a central stylar canal is lined by a transmitting tissue in *Nectaropetalum kaessneri* (Figs. 12, 28). The stigmatic lobes bear glandular hairs (Figs. 1, 12, 29).

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Floral Anatomy

The pedicel shows a ring of vascular bundles in *Aneulophus africanus* and *Erythroxylum* species (Figs. 2, 30) and a compact siphonostele in *Nectaropetalum kaessneri* (Fig. 13). A prominent band of sclerenchyma, in the form of a sheath surrounds the stele in the last taxon (Fig. 13). The conjoint sepal laterals and sepal midribs arise in two closely alternating whorls (Figs. 3–5, 14, 15, 31, 34, 35). In *Nectaropetalum kaessneri*, as the sepal traces leave the stele, the band of sclerenchyma around the main stele, becomes broken into a number of groups and these gradually enter the sepals along with the traces (Figs. 14–20). The petal traces arise independently from the main stele (Figs. 5, 32). However, in *Nectaropetalum* and *Erythroxylum lanceum* they are conjoint with the traces for the stamens opposite to them (Figs. 16–19, 34, 35). The traces supplying the petals divide and the inner branches enter the leafy appendages borne on the inner side of the petals in *Erythroxylum* species (Fig. 42). The traces for the ten stamens arise in one whorl in *Aneulophus africanus* and *Erythroxylum* species (Figs. 6, 33). In *Nectaropetalum kaessneri* and *Erythroxylum lanceum* however, the antepetalous staminal traces, conjoint with the petal midribs, are demarcated a little earlier than the antesepalous staminal traces, thus making the androecium obdiplostemonous (Figs. 16–19, 34, 35).

Since the vascular anatomy of the ovary in the three genera differs, they are described separately.

Aneulophus africanus : After the staminal traces are demarcated, the main stele forms three groups ; each group consists of an outer and two inner bundles (Fig. 7). The outer bundles function as the dorsal carpellary traces and the inner three pairs of bundles become the ventrals (Figs. 7–10). The dorsal carpellary traces at a higher l vel give rise to lateral branches which swing side ways and the branches of adjacent carpels come to lie at the base of each septum (Figs. 8–10). The dorsal carpellary traces as well as their branches fade away towards the top of the ovary. The ventrals of adjacent carpels form pairs and lie on the septal radii (Figs. 8–10). After the ovular supply is given off, the ventrals extend into the styles (Fig. 11) and fade away below the stigmas.

Nectaropetalum kaessneri : The main stele, after the staminal supply, is in the form of a closed ring (Fig. 19). Two dorsal carpellary traces arise from this stele (Fig. 20) followed by two pairs of median laterals. The remaining portion of the stele forms a pair of common ventrals, which lie at the base of the septum (Figs. 21–23). These produce branches, which supply the ovary wall along with the other traces (Fig. 22). The ventrals which are situated at the base of the septum to start with, gradually move towards the centre and divide to form a number of bundles arranged in the form of a ring (Figs. 22-25). The traces for the ovules are organized from the bundles lying along the radius of the dorsal carpellary traces (Fig. 25). After supplying the ovules, the vascular tissue gradually fades away. At this region the septum recedes slightly making the ovary one chambered (Fig. 26). At a higher level the septa meet again, fuse with each other and extend towards the dorsal region, where they finally fuse with the ovary wall. Thus, at this level the ovary presents a four chambered condition (Fig. 27). While all the other traces supplying the ovary fade towards the top of the ovary, the dorsal carpellary traces alone traverse the common style and ultimately reach the base of the stigmatic lobes (Figs. 12, 28). The central stylar canal is lined by a transmitting tissue (Fig. 28).

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EXPLANATIONS TO FIGURES

Figs. (1—11). *Aneulophus africanus*. (1) L. S. of flower (Lower part : K—Calyx ; C—Corolla ; A—Andro-ecium ; G—Gynoecium). (2—11) Serial transverse sections of flower. For explanation see text.

Figs. (12—28). *Nectaropetalum kaessneri*. (12) L S. of flower. (K—Calyx ; C—Corolla ; A—Androecium; G—Gynoecium). (13—28) Serial transverse sections of flower bud. For explanation see text.

Figs. (29, 34, 35, and 43). *Erythroxylum lanceum*. (29) L. S. Flower (K—Calyx ; C—Corolla ; A—Androecium ; G—Gynoecium). (34, 35) T. S. flower bud showing the origin of petal—stamen traces. (43) T. S. flower bud showing the petals, stamens and styles.

Figs. (30—33, 36—39). *Erythroxylum novogratanense*. Serial transverse sections of the flower bud. For explanations see text.

Figs. (40 and 41). *E. suberosum*. Transverse Sections of the ovary showing the four carpelled condition. Note the single fertile carpel, the formation of the plexes and origin of ovular traces.

Fig. (42) *E. pulchrum*. T. S. flower bud showing petals with leaf appendages on the inside, the free filaments of the stamens and the Gynoecium at the level of orgin of ovular traces.

ABBREVIATIONS

Sl.—Common sepal laterals ; Sm.—Sepal midrib ; Pt. —Petal trace ; St.—Staminal trace ; Pt. + St.—Common petal—Stamen trace.; St. T.—Staminal tube ; Dct.—Dorsal carpellary trace ; V.—Ventral carpellary trace ; Cv.—Common ventrals ; Ovt.—Ovular trace ; Pl.—Plexus.

FIGS. 2-5.

FIG. 1.

FIGS. 6-11.

13

14

15

16

17

18

19

20

22

23

12

A

G

C

K

24

25

26

Dct

Dct

Dct

CV

Dct

CV

Dct

St.T.

21

27

28
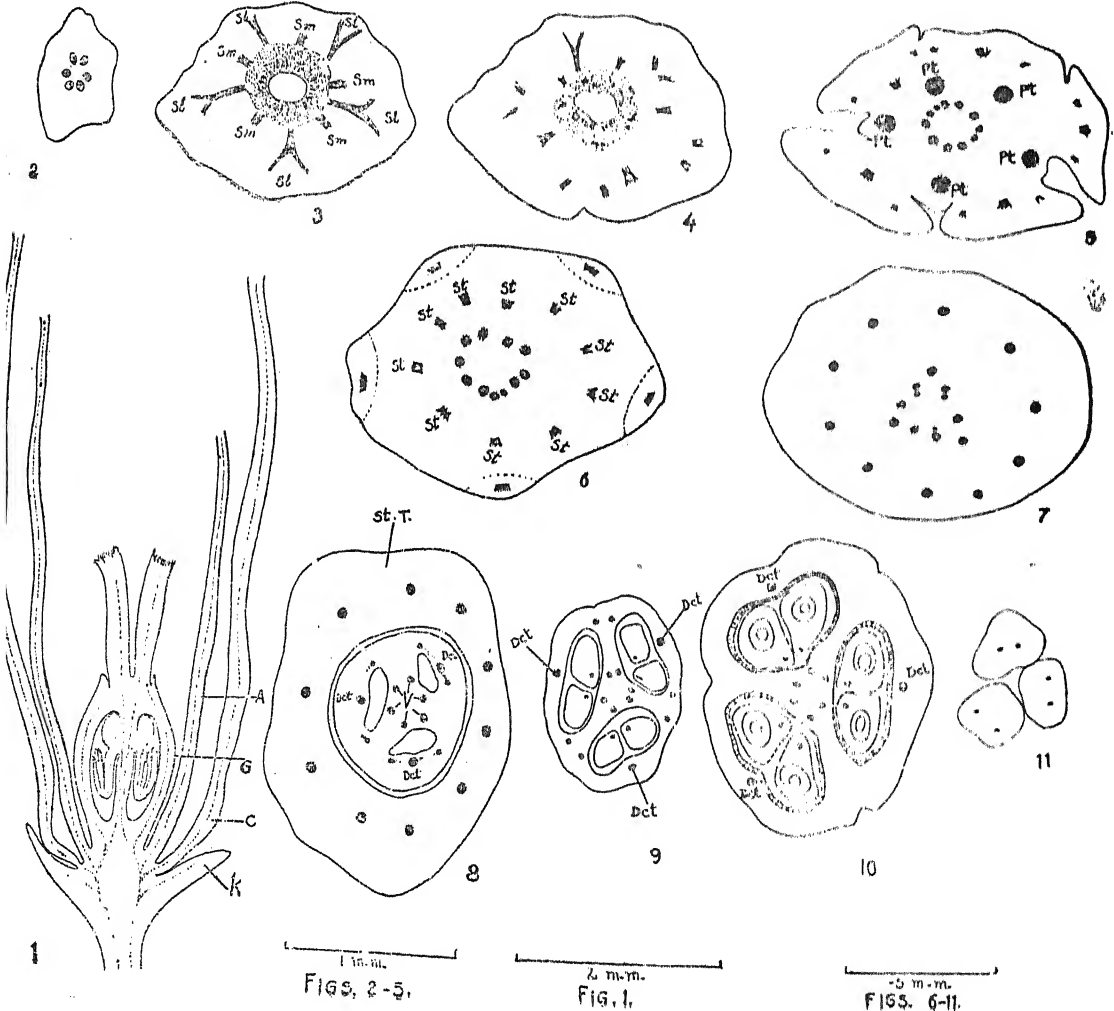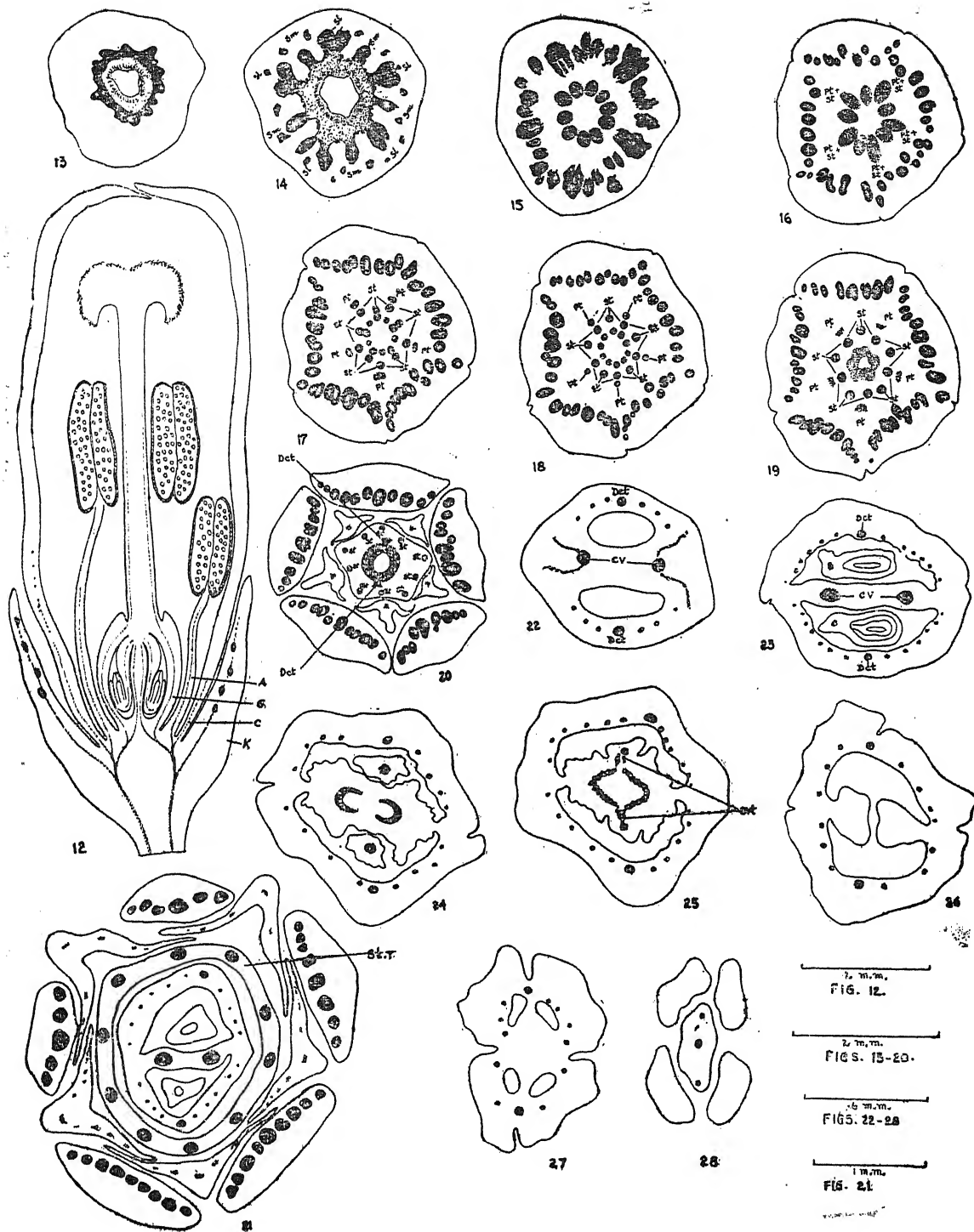
Erythroxylum : The main stele after the organization of the staminal traces, assumes a triangular or circular outline and soon splits into three groups (Fig. 36) ; of these, the group that is removed from the other two supplies the fertile carpel (Fig. 36). The other two groups constitute the supply for the sterile carpels (Fig. 36). Among the bundles in each group those distributed towards the periphery behave as the dorsal carpellary traces and the two pairs of bundles situated towards the centre constitute the ventral traces (Fig. 36). The remaining bundles divide and supply the ovary wall. Of the two pairs of ventrals, those lying on either side of the fertile carpel are distinct ; they represent the common ventrals formed by the fusion of the half ventrals of the ferttile carpel with one of the half ventrals of the adjacent sterile carpels (Figs. 37, 40). The other two traces in this region are the half ventrals of the sterile carpels and are smaller than the common ventrals (Figs. 37, 40). Thus, it is interesting to note that though the two of the carpels are sterile, their vascular supply is still persisting. Another noteworthy feature is the organization of two prominent plexes formed by the fusion of the ventrals of all the three carpels (Figs. 38, 39, 41, 42). Some of the bundles supplying the ovary wall, also get merged with the traces of the plexes. Two prominent traces, one from each plexus, supply the solitary ovule (Figs. 39, 41). Thus, the single ovule in *Erythroxylum* appears to receive the vascular supply of the sterile carpels and also the supply for the second suppressed ovule of the fertile carpel. The style is traversed by the dorsal carpellary traces, which gradually fade away in the stigmatic region (Fig. 29).

Discussion

A study of the floral anatomy of the Erythroxylaceae reveals that the basic plan of the flower is pentamerous and pentacyclic. The three traced sepals are valvate and are basally connate in *Erythroxylum*. The imbricate petals are single traced. Adnation between petal midribs and antepetalous staminal traces is seen only in *Nectaropetalum kaessneri* and *Erythroxylum lanceum*. Vascularized leafy appendages are formed on the inside of the petals in *Erythroxylum* species, while in *Nectaropetalum kaessneri* glands occur at the base of the petals.

Obdiplostemony, noticed in *Nectaropetalum kaessneri* and *Erythroxylum lanceum*, occurs in *Erythroxylum coca* and *E. mooni* (Narayana, 1960). However, there is no adnation between the antepetalous staminal traces and petal midribs in *E. mooni* (Narayana, 1960).

The placentation in *Aneulophus africanus* and *Nectaropetalum kaessneri* is axile and parietal in *Erythroxylum* species.

The vascular supply to the gynoecium varies in the three genera studied. The genus *Nectaropetalum* differs from the other two genera in having a bicarpellary, bilocular ovary with one ovule in each loculus. The mode of origin of the ovular traces differs from the other two genera.

Aneulophus africanus and *Erythroxylum* seem to be close, although the latter shows certain distinctive features in the structure of the gynoecium. The basic plan of the ovary in both genera appears to be the same. The altered picture in the vascular anatomy of the ovary in *Erythroxylum* is due to loss of fertility of two carpels out of the three ; further, there is the suppression of one of the ovules in the surviving carpel. The genus *Erythroxylum* appears to be distinct in having petals with leafy appendages and a tricarpellary ovary with one fertile carpel which is uniovulate ; this ovule receives traces from the two plexes formed by the fusion of the ventrals of both sterile and fertile carpels and also some of the bundles supplying the ovary wall.

While the similarities in the floral morphology of these three genera indicate a relationship, the striking differences noticed in the vascular plan of their ovaries are noteworthy.

Summary

The floral morphology of *Aneulophus africanus*, *Nectaropetalum kaessneri*, *Erythroxylum novogratananse*, *E. lanceum*, *E. pulchrum* and *E. suberosum* are described in a comparative manner.

The sepals are three traced and valvate. The petals are single traced and bear leafy appendages on the inside in *Erythroxylum*; in *Nectaropetalum kaessneri* glands are present at the base of the petals. There is adnation between petal midribs and antepetalous staminal traces in this taxon and *E. lanceum*. The stamens form a short tube at the base and are obdiplostemonous in *Nectaropetalum kaessneri* and *E. lanceum*. The ovary is bicarpellary, bilocular with one ovule in each loculus in *Nectaropetalum kaessneri*, tricarpellary trilocular with two ovules in each loculus in *Aneulophus africanus*, and tricarpellary with one fertile carpel bearing a solitary ovule in *Erythroxylum* species. The ovule in *Erythroxylum* species receives traces from the two plexes formed by the fusion of the ventrals and also some of the bundles supplying the ovary wall.

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SOME ADDITIONS TO THE FLORA OF RAJASTHAN

By

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Rajasthan presents floristically an interesting assemblage of species. Its vegetation is directly influenced by climate, soil and biotic factors. The Aravallis divides this state into two distinct climatic zones, *viz.*, West of Aravallis and East of Aravallis, and even so these two zones differ considerably from the view point of vegetation.

On the North-west, the area is mostly sandy desert dominated by African, Persian and Arabian elements and on the East of Aravallis, the vegetation is of dry tropical deciduous type having Central Indian affinities while the Aravallis itself supports a flora of Indo-Malayan and tropical elements.

Since King (1879), lot of work has been done on the flora, ecology etc. of this state by various workers *viz.*, Macadam (1890), Blatter and Hallberg (1918-21), Sarup (1951, 52, 54, 57–58), Nair *et al* (1956, 57, 59, 61), Raizada (1954, 61), Jain (1960, 62, 63), Bhandari (1962, 64), Rao and Kanodia (1962-63), Sharma (1958), Biswas and Rao (1953), Joshi (1956, 57 and 58), Sankhala (1951), Ramdeo (1960), Vyas (1962, 64), and of late Puri *et al* (1964) has published the Flora of Rajasthan, which includes areas lying west of Aravallis.

A thorough and critical study of literature reveals that though much work has been done on the flora of Western and Northern sectors of Rajasthan state the Southern and Eastern sectors have been almost neglected except one or two papers by Vyas *et al* (1964) and Ramdeo (1965). These areas are perhaps the richest regions of the state as far as floral composition is concerned. Keeping in view this fact, Botanical Survey of India, Central Circle after coming into existence in 1962, started exploration-cum-plant collection work in these regions.

Out of the six exploration tours in these parts made during August, 1962 to March, 1965, approximately 650 species were collected and after careful identification and thorough search of literature 42 species have come out as new records for the state which are hitherto not reported so far.

These species are enumerated in this paper with field data on habit, habitat, phenology and some morphological characters together with field nos. and exact locality.

The reference of *Flora of British India* by Hooker *et al* (1872–97) has been given to each species except in grasses where Bor (1960) has been referred because of recent and comprehensive work on Gramineae and for these references following abbreviations are used in the text :

    FBI   :   Flora of British India.

    Mon. Grasses :   The Grasses of Burma, Ceylon, India and Pakistan.

The specimens cited in this paper have been collected by the senior author and deposited in the Herbarium of Central Circle, Botanical Survey of India, Allahabad.

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CAPPARIDACEAE

Cleome monophylla Linn. ; FBI 1 : 168.

Annual herb upto 50 cm. high. Leaves simple. Flowers dull-purple. Bracts petiolate. Capsule upto 8 cm. long. Fairly abundant. Shahabad : Kundakhoh, 804. Flowers and fruits—August.

VIOLACEAE

Hybanthus enneaspermus (Linn.) F. V. Muell. in Fragm. 10 : 81, 1877. *Ionidium suffructicosum* Ging. ; FBI 1 : 185.

Perennial herb upto 20 cm. high. Flowers bluish. Capsule globose. Fairly abundant. Shahabad : Kundakhoh, 808. Flowers and fruits—August.

POLYGALACEAE

Polygala chinensis Linn. ; FBI 1 : 204.

Annual herb upto 20 cm. high. Flowers yellow, in short capitate racemes, wings herbaceous. Fairly abundant along roadside and in moist places. Shahabad, 663, 765 ; Chittorgarh : Bansi, 1745 ; Bundi, 1866. Flowers and fruits—August—December.

Polygala elongata Klein ; FBI 1 : 203.

Annual herb upto 20 cm. Flowers yellow, in long racemes. Rare, along streams. Shahabad : Kapildhara, 781. Flowers and fruits—August.

GERANIACEAE

Biophytum sensitivum DC. ; FBI 1 : 436.

Annual herb upto 15 cm. high. Leaves crowded into a rosette at top of stem. Flowers yellow. Fairly abundant in wastelands and along forest. Chittorgarh, 1615. Flowers—December.

RHAMNACEAE

Zizyphus oenoplia Mill. ; FBI 1 : 634.

A straggling shrub upto 3 m. high. Leaves obliquely ovate-lanceolate, silky hairy beneath. Flowers greenish. Fairly abundant. Shahabad : Puraniya, 748. Flowers—August.

AMPELIDACEAE

Cissus adnata Roxb. Fl. Ind. 1 : 405, 1820. *Vitis adnata* Wall. ; FBI 1 : 649.

A scandent shrub. Leaves simple, clothed with orange-red pubescence. Fruits reddish. Fairly abundant. Pratapgarh : Rampuriya, 269. Fruits—April.

LEGUMINOSAE

Atylosia scarabaeoides Benth. ; FBI 2 : 215.

A climbing herb with slender branches. Leaves trifoliolate, exstipullate, pubescent, deeply nerved. Pod hairy, 5-6 seeded with deep lines between the seeds. Fairly abundant. Banswara, 245 and 251. Shahabad : Kundakhoh, 811 ; Chittorgarh, 1641. Flowers and fruits—August—April.

Desmodium latifolium DC. ; FBI 2 : 168.

A scandent shrub upto 1 m., in mixed forests ; stem fulvous hairy. Leaflet single, ovate, scabrous. Flowers deep viotet, in long racemes. Fairly abundant. Shahabad, 616. Flowers—August.

Millettia auriculata Baker ; FBI 2 : 108.

A liana in mixed forests. Leaflets obovate. Pods in racemes, flattened, thickly sutured, covered with light chocolate coloured tomentum. Fairly abundant. Shahabad : Kundakhoh, 800. Fruits—August.

Moghania nana (Roxb.) Mukerjee, in Bull. bot. Soc. Beng. 6 : 20, 1952. *Flemingia congesta* Roxb. var. *nana* Baker ; FBI 2 : 229.

A perennial branched herb upto 10 cm. Flowers attractive, pink-blue. Fairly abundant in mixed forests in rock crevices. Chittorgarh : Deogarh, 250. Flowers—April.

Teramnus labialis (Linn.) Spreng. ; FBI 2 : 184.

A spreading climber. Leaves trifoliolate, membranous, slightly hairy below. Pods flat, slightly incurved, hooked with a short beak. Fairly abundant on hedges. Banswara, 247. Flowers and fruits—April.

Uraria picta Desv. ; FBI 2 : 155.

A perennial herb, covered with stiff hairs. Flowers blue violet or purple, in cylindrical racemes upto 30 cm. long. Rare, along roadside in the shade. Shahabad-Kishanganj, 702 ; Kishanganj Forests nursery, 704. Flowers and fruits —August.

COMBRETACEAE

Combretum ovalifolium Roxb. ; FBI 2 : 458.

A climbing shrub. Fruits nearly globose with four membranous reddish wings. Fairly abundant in Teak forests. Banswara, 222. Fruits—April.

LYTHRACEAE

Rotala rotundifolia Koehne, in Bot. Jarhb. 1 : 177, 1880. *Ammannia rotundifolia* Ham. ; FBI 2 : 566.

An annual green herb turning pinkish on maturity, rooting at lower nodes. Leaves broadly ovate-orbicular. Flowers in congested spikes. Abundant in moist ditches and dried up riverbed. Jhalawar : Kalisind river, 3382, 3384. Flowers and fruits—April.

Rotala tenuis (Wight) Koehne, in Bot. Jarhb. 1 : 177, 1880. *Ammannia tenuis* C. B. Clarke ; FBI 2 : 567.

Annual slender erect to slightly creeping pinkish green herb. Leaves elliptic-ovate, opposite. Flowers in dense terminal spikes. Abundant in mud and rock crevices along rivers and streams. Chittorgarh : Orai Dam site, 1675 ; Jhalawar : Kalisind river bank, 3390. Flowers and fruits—December-April.

FICOIDEAE

Mollugo pentaphylla Linn., Sp. Pl. 89, 1753. *M. stricta* Linn. ; FBI 2 : 663.

Annual herb upto 20 cm. high. Leaves whorled, narrowed at base. Flowers pinkish-green, in compound cymes. Capsule globose ; seeds dark reddish-brown,

tubercled. Fairly abundant on black cotton soil. Kishanganj : Kanya Deh, 719. Flowers and fruits—August.

EBENACEAE

Diospyros cordifolia Roxb. ; Cor. Pl. t. 50. *D. montana* Roxb. var. *cordifolia* C. B. Clarke ; FBI 3 : 555.

Tree upto 6 m. ; bark blackish. Leaves oblong-lanceolate, pubescent. Fruits orange-yellow, becoming black on drying. Fairly abundant. Chittorgarh : Senwa, 1622. Fruits—December.

Diospyros montana Roxb. ; FBI 3 : 555.

Tree upto 6 m. high. Leaves ovate-elliptic. Fruits globose, distorted, blackish-brown. Abundant in *Angeissus pedula* forests, on lower slopes. Udaipur : Banki, 33. Fruits—April.

ASCLEPIADACEAE

Marsdeuia tenacissima W. and A. ; FBI 4 : 35.

A densely brown tomentose climber on roadside trees. Leaves broadly ovate, deply cordate, tomentose. Flowers yellowish-white, in much branched corymbose cymes. Rare. Shahabad-Kishanganj near 12th Km. stone, 671. Flowers—August.

SCROPHULARIACEAE

Lindernia ciliata (Colsm.) Pennell, in J. Arn. Arb. 24 : 253, 1943. *Bonnaya brachiata* Link. and Otto. ; FBI 4 : 284.

Annual herb upto 10 cm. Leaves serrate. Flowers pink, in lax terminal raceme. Capsule much longer than calyx. Fairly abundant on black cotton soil. Kishanganj : Kanya Deh, 710. Flowers and fruits—August.

LENTIBULARIACEAE

Utricularia exoleta R. Br. ; FBI 4 : 329.

Aquatic herb with submerged multifid leaves. Flowers yellow, 1–2, on slender emerged peduncle. Abundant in pond near Rest House, Banswara, 214. Flowers and fruits—April.

LABIATAE

Acrocephalus indicus (Burm.) O. Ktze., in Rev. Gen. Pl., 511, 1891. *A. capitatus* Benth ; FBI 4 : 611.

Annual herb upto 20 cm. high. Flowers in dense terminal ovoid heads with a pair of floral leaves and imbricate bracts. Fairly abundant in rock crevices. Sawaimadhopur : Bondal, 1917. Flowers—December.

Hyptis suaveolens (Linn.) Poit. ; FBI 4 : 630.

A hairy undershrub. Leaves broadly ovate sinuate-serrulate. Flowers blue-violet ; calyx sub-equal 5 lobed. Abundant on wasteland near Rawat Bhata Dam, Chandrapura, 1843. Flowers—December.

Orthosiphon pallidus Royle ; FBI 4 : 613.

A perennial herb ; branches upto 20 cm. high from a woody root-stock. Leaves long petioled, toothed. Flowers white with brown streaks. Fairly abundant. Shahabad, 622 ; Kota Naka, 409, 472. Flowers—August.

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DIOSCOREACEAE

Dioscorea hispida Dennst., in Schluss. Hort. Malab. 15, 1818. *D. daemona* Roxb. ; FBI 6 : 289.

A climber. Capsule honey coloured, imbricate becoming glabrous and pendulous on maturity, the wings about 5 cm. by 1 cm., sometimes their margin freed in dehiscence and look like a fine wire. Fairly abundant. Udaipur : Parshad, 121. Fruits—April (late stage).

PONTEDERIACEAE

Monochoria hastata (L.) Solms., in A.DC. Mon. Phan. 4 : 523, 1883. *M. hastaefolia* Presl. ; FBI 4 : 362.

Perennial aquatic plant. Mature leaves triangular ovate, hastate. Flowers blue, contorted anticlockwise ; anthers yellow. Fairly abundant near Sitakund, Shahabad-Kishanganj, 689. Flowers—August.

NAIADACEAE

Zannichellia palustris Linn. spp. *pedicellata* Wahlenberg and Rosen. ; FBI 6 : 568.

Submerged slender perennial herb with copiously branched leafy stem. Drupelets usually four, compressed, slightly curved with long tip, toothed along margins, Abundant. Jhalawar : Jhanganbara stream, 3379. Fruits—April.

GRAMINEAE

Alloteropsis cimicina (Linn.) Stapf. ; Mon. Grasses : 276.

Annual slender grass, hairy all over, upto 20 cm. high. Spikelets awned, reddish on margins, arranged in one sided spikes. Fairly abundant along roadside. Shahabad : Kota Naka, 451. Flowers—August.

Chrysopogon fulvus (Spreng.) Chiov. ; Mon. Grasses : 116.

Perennial tufted grass upto 1·5 m. high. Spikelets with chocolate coloured awns ; pedicels shorter than half the length of the sessile spikelets ; hairs on the spikelets golden-yellow. Abundant among rocks. Chittorgarh : Senwa forest, 1617. Flowers—December.

Eriochloa procera (Retz.) C. E. Hubb. ; Mon. Grasses : 312.

Perennial grass upto ·75 m. high, on black loamy soil. Spikelets pointed, silvery hairy, axis glabrous. Fairly abundant. Kishanganj, 744. Flowers—August.

Hemarthria protensa Steud. ; Mon. Grasses : 161.

Perennial grass, colonising in patches along river bank. Spikelets in cylindrical spikes ; upper glume long tailed. Abundant. Bundi : Mangli river bank, 1867. Flowers—December.

Panicum austroasiaticum Ohwi ; Mon. Grasses : 324.

Annual grass upto 20 cm. high. Spikelets whitish, about 1·4 mm., in panicles ; seeds blackish. Abundant in open fields. Kishanganj : Kapildhara, 776. Flowers—August.

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Panicum atrosanguineum Hochst. ex A. Rich. ; Mon. Grasses : 323.

Annual diffused grass, covered with long hairs. Spikelets green when young, turning purple-violet on maturity. Abundant along roadside. Shahabad : Kota Naka, 428, 429, 436.

Panicum repens Linn. ; Mon. Grasses : 230.

Perennial grass with a pointed rhizome. Leaf blades involute, glaucous-Lower glume almost cup-shaped. Fairly abundant in wastelands. Shahabad. Kishanganj, 688. Chittorgarh : Bansi, 1771. Flowers August-December.

Paspalidium flavidum (Retz.) A. Camus ; Mon. Grasses : 333.

Annual decumbent, stem upto 1 m. long. Spikelets ovate orbicular, spikes shorter than the internodes, rachis protruded. Shahabad : Kota Naka, 449, 455 ; Kishanganj, 670. Flowers—August.

Phragmites karka (Retz.) Trin. ex Steud. ; Mon. Grasses : 416.

Perennial upto 2·5 m. high, bearded at the bases of lower panicle branches. Panicle large, feathery ; lower lemma upto 11 mm. long. Abundant along banks. Udaipur : Jaismand lake, 85. Flowers—April.

Polypogon monspeliensis (Linn.) Desf. ; Mon. Grasses : 403.

Annual upto 15 cm. high. Panicles dense, greenish-white on maturity ; spikelets long awned. Fairly abundant in moist habitat. Udaipur, 1 ; Jaismand, 79. Flowers—April.

Sporobolus indicus auctt. non Linn. R.Br. ; Mon. Grasses : 631.

Perennial grass, swollen and slightly pubescent at base. Panicle reddish-green, subspiciform and interrupted. Fairly abundant on black clayey soil. Shahabad, 442 ; Chittorgarh : Bansi, 1717. Flowers—August-December.

Setaria italica (Linn.) P. Beauv. ; Mon. Grasses : 362.

Annual grass upto 15 cm. Bristles on spikes antrosely barbed, spikelets persistent. Fairly abundant on deep black loamy soil. Kishanganj, 742. Flowers—August.

Themeda laxa (Anderss.) A. Camus ; Mon. Grasses : 251.

Perennial grass upto 1·25 m. high. Spikelets awned, in very loose leafy panicle. Fairly abundant along cultivated fields and mixed forests. Kishanganj ; Puraniya, 706, 754. Flowers—August.

Themeda triandra Forsk. ; Mon. Grasses : 254.

Perennial grass upto 1·5 m. high. Spikelets in panicles of loosely arranged congested heads. Abundant in wastelands and along forests. Chittorgarh : Semalpura, 1637, 1652 ; Bansi, 1729. Flowers—December.

Summary

In this paper, 42 species are recorded for the first time from Rajasthan and are additions to the flora of this state. These have been collected mainly from the South and Eastern regions. The important morphological characters along with notes on habit, habitat, field nos. and place of collection etc. have also been given against each species.

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STUDIES ON THE EFFECTS OF CARBON AND NITROGEN ON MACRO-CONIDIAL, MICRO-CONIDIAL AND CHLAMYDOSPORE PRODUCTION IN *FUSARIUM UDUM* BUTLER

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Introduction

Vascular wilt of pigeon pea (*Cajanus cajan* (Linn.) Millsp.) commonly known as Arhar wilt in northern India is of widespread occurrence. This soil-borne disease causes considerable loss to the standing crop in Chotanagpur, Bihar. The fungus was first identified by Butler in 1910 in India.

Srinivasa Pai (1953) working with *Fusarium vasinfectum* and *Fusarium moniliforme* cultures studied the effect of carbon, nitrogen and hydrogen-ion concentrations on the two fungi. He mainly worked out the dry weight of mycelia as effected by different nitrogen sources such as $(NH_4)_2 SO_4$, KNO_3 urea and peptone. Both Fusaria however showed marked difference in their utilization of nitrogen and sugar. Source of nitrogen also effected the percentage amount of nitrogen in the fungal mat varying greatly in the two fungi. Wilson (1960) studied the growth and sporulation of an isolate of *Fusarium oxysporum f. cubense* (E. F. Sm.) Snyd. Hans under different carbon and nitrogen concentrations. S. Subramanian (1961) worked on the growth of *F. udum* when subjected to twenty two different carbon sources and found that glycerol served best for fungal growth and lactic acid for sporulation.

The present investigations were made to study the effects of carbon and nitrogen separately as well as conjointly on the culture of *F. udum* Butler. Quantitative estimation of the three spore forms namely macro-conidia, micro-conidia and chlamydospores in culture has been undertaken for the first time.

Materials and Methods

A. Materials used—

The pathogen, *F. udum* Butler was isolated from diseased pigeon pea plants of Ranchi. Isolation was made on PDA, the pH of the medium being adjusted to 6·0. The identity of the isolate was established with the help of pathogenicity tests carried out in our laboratory. The technique applied for the preparation of media, sterilisation and maintenance of the culture was in accordance with that of Rawlins (1933). Dark-pink colonies appeared on the PDA medium within 7 to 10 days at an incubation of 26–30°C. The thickness of the mycelium is $1·5\mu$ to 4μ. The diameter of the chlamydospore being $4–10\mu$. They are formed intercalarily as round thick-walled bodies (Fig. 1). Macro-conidia are long incurved and are pointed at the ends, being 6–7 septate (Fig. 2), measuring between 15 to $19\mu \times 3$ to 5μ. Micro-conidia are two septate, smaller in size measuring 5 to $9\mu \times 2$ to 4μ.

The basal culture medium contained the following ingredients as recommended by Wilson (1960) alongwith the varying carbon and nitrogen content :

$MgSO_4$ $7H_2O$ ...   2·22 gm
KH_2PO_4 ...   3·46 gm
K_2HPO_4 ...   1·105 gm

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To the above ingredients in seven separate 1 L flasks were added seven series of carbon-variants. Sucrose served as source of carbon. The seven carbon-variants contained 0·00 gm/L, 0·104 gm/L, 0·212 gm/L, 0·420 gm/L, 0·840 gm/L, 1·680 gm/L and 3·368 gm/L of sucrose respectively. $(NH_4)NO_3$ served as source of nitrogen. Six different concentrations of nitrogen source were added to each of the seven carbon-variants (Table 1). $(NH_4)NO_3$ added were of the following strengths namely 0·00 gm/L, 0·0077 gm/L, 0·0154 gm/L, 0·030 gm/L, 0·061 gm/L and 0·122 gm/L. All told 42 different media of varying carbon-nitrogen concentrations were made. Bacto-Agar (2%) was added as solidifying agent. The chemicals used were from B. D. H. The medium was then sterilised at 15 lbs. pressure for 15 minutes. Transfers were then made from stock-culture to each of the variant. For each of them five replicates were incubated at 26-28°C for 3-4 weeks.

B. Counting and calculation of different spore forms and dry weight estimations—

In sterile distilled water 10 cc of the spore suspension was made. A drop of the spore suspension was then transferred to a haemocytometer slide of Fine Optik, Jena, Germany make and of known depth (0·01 cm). A definite area of 0·000256 sq. cm secured in a special eye-piece of Leitz Wetzlar make served as the microscopic field. This area multiplied by the depth of the haemocytometer slide gave the volume of the spore suspension being 0·000000256 cc (0·000256 sq. cm × 0·01 cm). 100 microscopic fields for each of the five replicates were counted and the mean value of the different spore forms per microscopic field estimated separately. This mean value when multiplied with the calculated conversion factor gave the amount of different asexual bodies in 10 cc of the spore suspension.

Dry weight estimations on Whatman Filter paper No. 41 was done according to the method of Pinck and Allison (1944) and Srinivasa Pai (1953).

Experimental Results and Discussion

First series : In the first series only seven carbon variants alongwith the other basal ingredients was introduced. No nitrogen source was added. The amount of macro-conidia, micro-conidia and chlamydospores as well as the total amount of asexual bodies (in millions per 10 cc of suspension) has been plotted in Fig. 4 and included in Table 1. As is evident from Fig. 4 and Table 1 the amount of macro-conidia varied from 0·04 millions to 0·50 millions per 10 cc. However it showed an increase with the increase in the amount of carbon added. The micro-conidial population was comparatively larger varying from 2·00 millions to 4·30 millions. In contrast to the above two spore forms chlamydospore population was much larger ranging from 0·66 millions to 19·40 millions. All the more it showed a vigorous increase in the amount with the increase in carbon-source. To the contrary micro-conidial formation in absence of nitrogen does not respond well with the increase in the amount of carbon content. It seems that chlamydospore formation is unaffected by the absence of nitrogen. The total number of asexual bodies varied from 2·60 to 24·20 millions per 10 cc, the bulk of the population being contributed mainly by chlamydospores.

Dry weight of the fungal mat varied from 0·100 gm to 0·750 gm showing an increase parallel to that of the carbon source. This indicated that carbon is incorporated in the mycelium (Fig. 10, Table 2).

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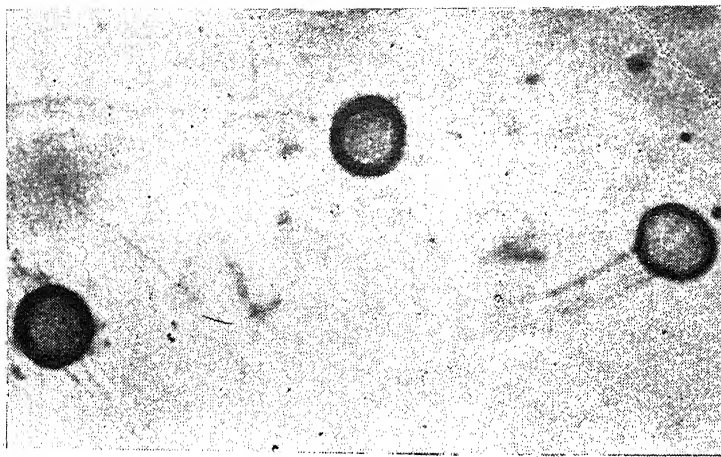
Fig. 1. Dark, thick walled chlamydospores ; diameter $7\cdot5\mu$.

Fig. 2. Macro-conidia ; 6–7 septate, pointed and incurved at the tips. Size $16\cdot5\mu\times4\cdot2\mu$.
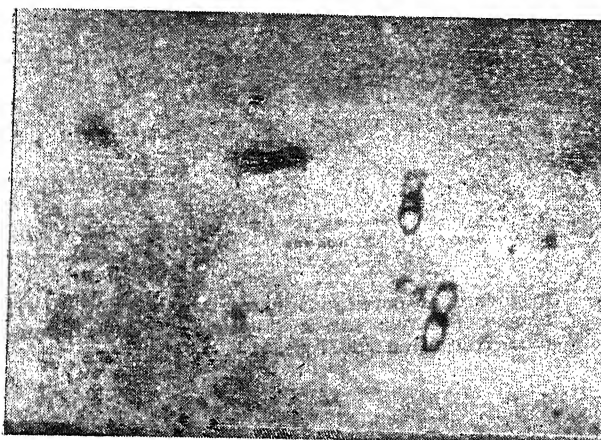
Fig. 3. Micro-conidia ; 2 septate. Size $5\mu\times2\cdot5\mu$.
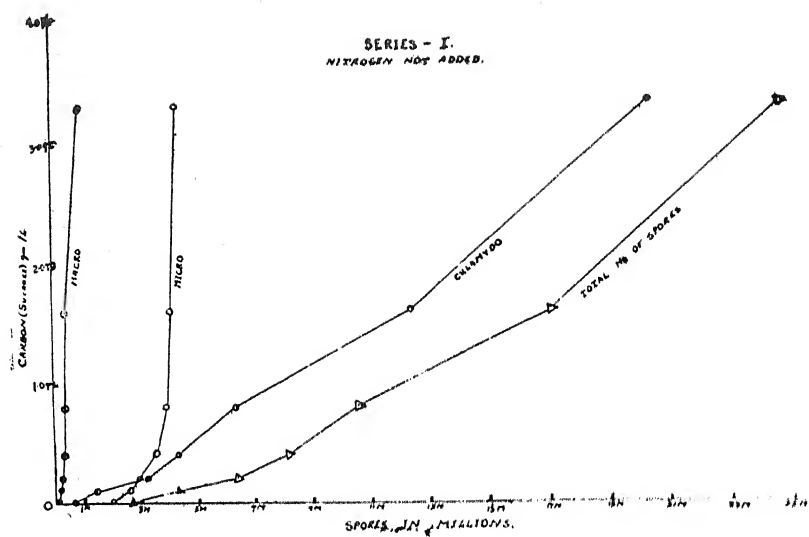
Fig. 4. The amount of spore forms (in millions) varyiug with the amount of carbon source (Sucrose) ; Nitrogen not added.
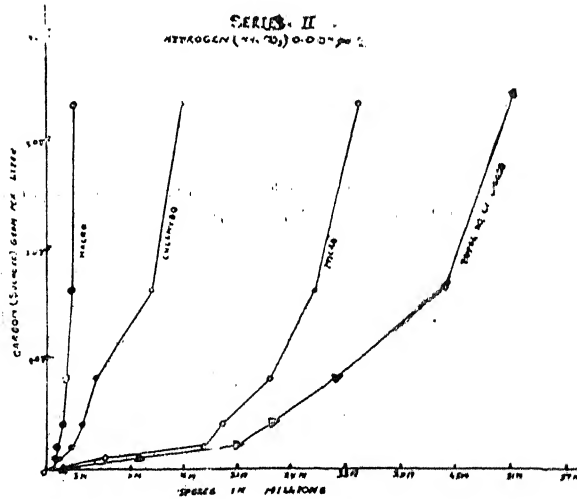
Fig. 5. The amount of spore forms (in millions) varying with the amount of carbon-source (Sucrose) ; Nitrogen source (NH$_4$)NO$_3$ being 0·0077 gm/L.

Second series : In the second series in each of the seven carbon variants 0·0077 gm/L of (NH₄)NO₃ as nitrogen source was added and the spore population estimated. In this case macro-conidial population ranged from 0·62 millions, to 2·96 millions, micro-conidial from 0·40 to 35·15 millons and chlamydospores from 0·58 to 15·62 millions. The total number of asexual bodies range between 1·60 to 53·75 millions (Fig. 5, Table 1). On the whole with the addition of nitrogen a relative shift in the population density of spore forms occur as compared to the previous case. The added nitrogen alongwith the increase in carbon content appears to stimulate micro-conidial formation, at the same time suppressing to an extent chlamydospore formation. The macro-conidia seems to remain unaffected.

Dry weight of the fungal mat also showed a corresponding increase ranging from 0·05 gm to 1 gm indicating that carbon was utilized by the fungal mat (Fig. 10, Table 2).

Third series : In the third series similar carbon-variants were taken. The amount of nitrogen being 0·0154 gm/L. The macro-conidial population varying from 1·29 to 4·29 millions, the micro-conidial from 4·72 to 38·82 millions and chlamydospores from 0·50 to 13·08 millions. The total asexual bodies ranged between 6·52 to 56·21 millions, the major sharer being micro-conidia (Fig. 6, Table 1). We find that increase in the macro-conidial population is uniform. Increase of micro-conidial population as compared to the previous series is only slight. On the other hand chlamydospore population decreases.

Dry weight of the mycelium also shows an increase from 0·05 to 1·05 gm indicating that carbon and nitrogen both are utilized by the fungal mat (Fig. 10, Table 2).
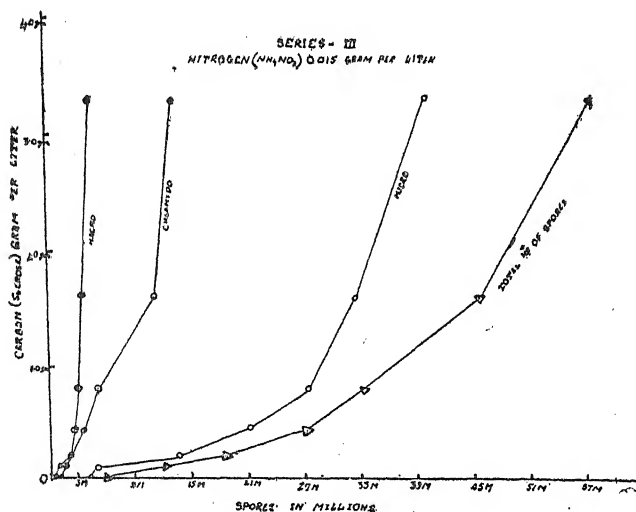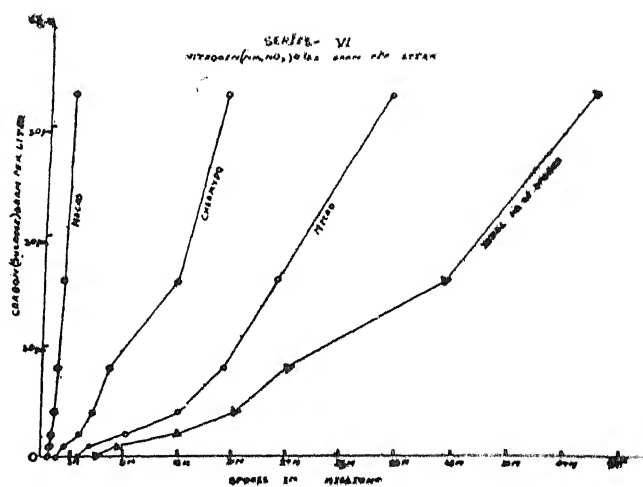

Fig. 6. The amount of spore-forms (in millions) varying with the amount of carbon-source (Sucrose) ; Nitrogen source (NH₄)NO₃ being 0·0154 gm/L.

Fourth series : The amount of nitrogen added to the seven carbon-variants this time is 0·030 gm/L. The macro-conidial population varied between 1·56

to 5·20 millions, micro-conidial from 5·11 to 53·08 millions and chlamypospores from 0·43 to 11·61 millions. The total amount of asexual bodies being 7·11 to 69·88 millions, the maximum coming from micro-conidia (Fig. 7, Table 1). In this series macro-conidial production was larger than the previous series. Micro-conidial population showed a phenomenal increase whereas there was a decrease in chlamydospore production. This suggests that 0·030 gm/L of nitrogen favours the maximum production of micro-conidia.

Dry weight of fungal mat showed a rapid increase from 0·35 gm to 1·10 gm. This shows that both carbon and nitrogen are incorporated in a balanced manner in the fungal mat (Fig. 10, Table 2).
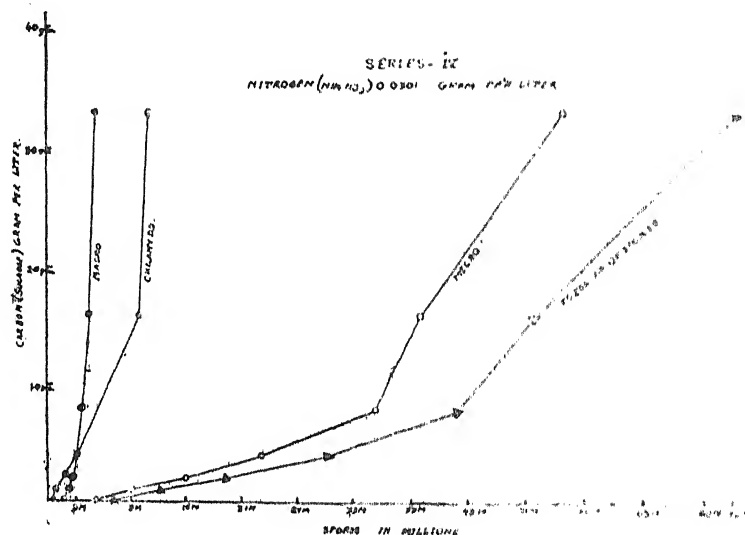
Fig. 7. The amount of spore forms (in millions) varying the amount of carbon-source (Sucrose) ; Nitrogen source (NH₄)NO₃ being 0·030 gm/L.

Fifth series : In the fifth series 0·061 gm/L of nitrogen source was added. The macro-conidial population varied from 1·25 to 4·25 millions, micro-conidial from 4·53 to 40·11 millions and chlamydospores from 0·74 to 19·53 millions. The total amount of asexual bodies ranged from 6·52 to 63·90 millions (Fig. 8, Table 1). For the first time a tendency towards decreased production of micro-conidia was evident. There was a decrease in the macro-conidial population as well. On the other hand the chlamydospore production again shot higher showing thereby that continual decrease from series to series in the amount of chlamydospore is now checked and higher concentration which becomes unfavourable to macro– and micro-conidia does not have any effect on them, rather it enhances the rate of chlamydospore production.

Dry weight of the fungal mat however shows a decrease ranging from 0·150 gm to 0·0700 gm. It shows that higher nitrogen content does not get incorporated in the fungal mat (Fig. 10, Table 2).

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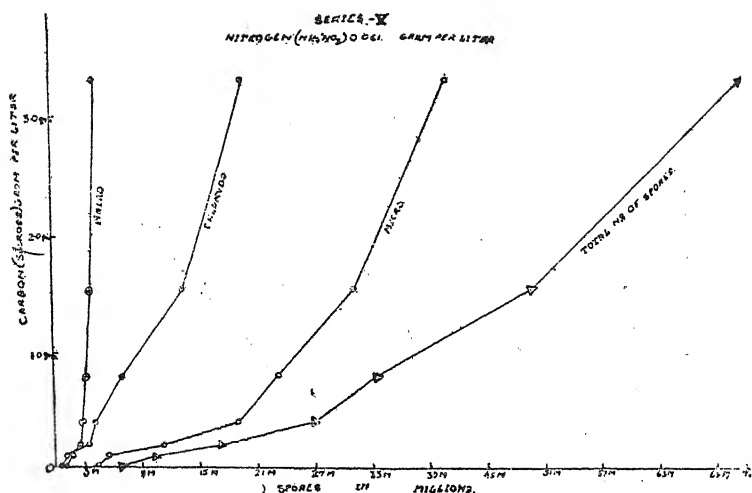
Fig. 8. The amount of spore forms (in millions) varying with the amount of carbon-source (Sucrose) ; nitrogen source $(NH_4)NO_3$ being 0.061 gm/L.

Sixth series : In the sixth series 0.122 gm/L of nitrogen-source was added. The macro-conidial population varied from 0.31 to 2.73 millions, micro-conidial from 4.16 to 38.86 millions and chlamydospore from 1.44 to 19.92 millions. The total number of asexual bodies ranging between 5.91 to 61.52 millions (Fig. 9, Table 1). Although the micro-conidial and chlamydospore population remained at the same level as the previous series showing that further doubling the amount of nitrogen source does not necessarily change the population dynamics, a remarkable phenomenon in the sudden decrease in the amount of macro-conidia was evident for the first time. It may be that additional nitrogen acts as an inhibitor to the macro-conidial production.

Dry weight of the mycelium also decreased and ranged from 0.10 to 0.55 gm (Fig. 10, Table 2). This also shows that nitrogen in this range acts as a deterrent for the fungal growth and could not be incorporated in the mycelium.

Interseries comparisons of the available data bring out a few more points of interest. For macro-conidial production carbon and nitrogen in the proportion of 3.368 to 0.030 gm/L yielded best results giving altogether 5.20 millions. The same series produced highest of micro-conidia as well being 53.08 millions. Because of such a high micro-conidial population the total amount of asexual bodies was also highest being 69.88 millions. In conformity with the above the dry weight of the fungal mat is also highest being 1.100 gm. Thus the maximum amount of carbon and nitrogen is accumulated by the fungus in this range. Increase in the amount of nitrogen had an adverse effect at least on the macro-conidial and micro-conidial production and also decreased the dry weight of the fungal mat.

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Fig. 9. The amount of spore forms (in millions) varying with the amount of carbon-source (Sucrose) ; Nitrogen source $(NH_4)NO_3$ being 0.122 gm/L.
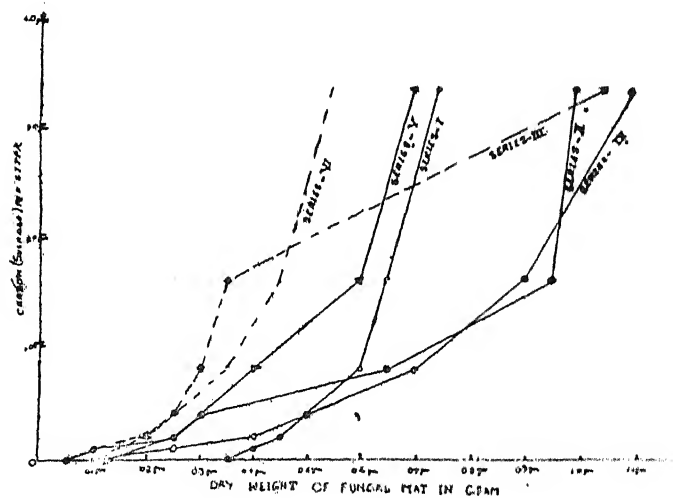
Fig. 10. Dry weight of the fungal mat varying with the amount of carbon-nitrogen content.

The entire results have been shown in the following 2 tables.

TABLE 1

Production of different spore forms (In millions per 10 cc) as effected by varying concentrations of carbon and nitrogen

N in gm/L.	C in gm/L.						
	0·000	0·104	0·212	0·420	0·840	1·680	3·368

MACRO-CONIDIA (in millions)

N in gm/L.	0·000	0·104	0·212	0·420	0·840	1·680	3·368
0·0000	0·04	0·17	0·19	0·27	0·35	0·43	0·50
0·0077	0·62	0·90	1·29	1·64	1·99	2·50	2·96
0·0154	1·29	1·60	1·99	2·50	2·96	3·51	4·29
0·0300	1·56	1·99	2·65	3·24	3·78	4·64	5·20
0·0610	1·25	1·71	2·30	2·73	3·16	3·86	4·25
0·1220	0·31	0·74	0·97	1·33	1·60	2·03	2·73

MICRO-CONIDIA (in millions)

N in gm/L.	0·000	0·104	0·212	0·420	0·840	1·680	3·368
0·0000	1·99	2·65	2·92	3·55	3·90	4·10	4·30
0·0077	0·40	7·81	17·67	19·53	25·07	30·35	35·15
0·0154	4·72	8·98	14·62	21·28	25·74	30·80	38·82
0·0300	5·11	9·33	15·00	23·40	35·11	40·54	53·08
0·0610	4·53	6·71	11·09	19·29	23·32	31·68	40·11
0·1220	4·16	5·11	9·50	15·10	20·11	28·00	38·86

CHLAMYDOSPORES (in millions)

N in gm/L.	0·000	0·104	0·212	0·420	0·840	1·680	3·368
0·0000	0·66	1·40	3·24	4·33	6·25	12·38	19·41
0·0077	0·58	1·21	2·73	3·94	5·54	11·71	15·62
0·0154	0·50	1·01	2·03	3·55	5·11	11·17	13·08
0·0300	0·43	0·74	1·75	3·24	4·64	1o·19	11·61
0·0610	0·74	1·79	3·75	4·49	6·95	13·71	19·53
0·1220	1·44	2·30	4·33	5·42	7·77	14·80	19·92

TOTAL ASEXUAL BODIES (in millions)

N in gm/L.	0·000	0·104	0·212	0·420	0·840	1·680	3·368
0·0000	2·69	4·24	6·36	8·16	1o·5o	16·91	24·21
0·0077	1·60	9·93	21·70	25·11	32·61	44·56	53·75
0·0154	6·52	11·64	18·64	27·34	33·82	45 49	56·21
0·0300	7·11	12·07	19·41	29·88	43·55	51·20	69·68
0·0610	6·52	10·23	17·14	26·52	33·43	49·25	63·90
0·1220	5·91	8·16	14·80	21·86	29·49	44·84	61·52

TABLE 2

Dry weight of the fungal mat (in gms.) as effected by varying concentrations of carbon and nitrogen

N in gm/L.	C in gm./L						
	0·0000	0·104	0·212	0·420	0 840	1·680	3·368
0·0000	0·100	0·250	0·400	0·500	0·600	0·650	0·750
0·0077	0·050	0·100	0·250	0·300	0·650	0·950	1·000
0·0154	0·050	0·100	0·200	0·250	0·300	0·350	1·050
0·0300	0·350	0·400	0·450	0·500	0·700	0 900	1·100
0·0610	0·150	0·200	0·250	0·300	0·400	0·600	0·700
0·1220	0·100	0·150	0·200	0·250	0·350	0·450	0·550

Chlamydospore formation however is independent of the availibility of nitrogen source. The production of chlamydospore is very erratic and they fall out of the usual pattern which governs the macro— and micro-conidial production. Chlamydospore production in absence of nitrogen as well as in its maximum strength gives identical values. This indicates that chlamydospore formation is not governed by nitrogen.

Summary

In order to study the effect of carbon and nitrogen on the growth and sporulation of *Fusarium udum* Butler seven carbon-source variants in six different series of nitrogen concentrations were observed. Sucrose served as carbon-source whereas $(NH_4)NO_3$ as source of nitrogen. Altogether 42 media of different carbon-nitrogen combination were inoculated and the population density of macro-conidia, micro-conidia and chlamydospores as well as their interrelationships was tabulated. Dry weight of the fungal mat in each case was estimated. The best yield of macro-conidia and micro-conidia were obtained in the medium containing carbon and nitrogen in the proportion of 3·368 : 0·030 gm/L. Dry weight of the fungal mat too was maximum indicating that maximum carbon nitrogen is absorbed. Further increase in nitrogen concentration inhibits the inclusion of nitrogen by the fungal mat.

Chlamydospore production however was erratic and independent of nitrogen concentration showing almost identical values both in its absence as well as in its maximum strength.

An inversely proportional relationship existed between micro-conidial and chlamydospore production in the sense that in all such series where micro-conidial production was at its maximum chlamydospore formation was less. In absence of nitrogen with the increase in carbon there was a very rapid increase in chlamydospore production. On the other hand micro conidial production was inhibited in absence of nitrogen. However in the next series it was found that with the slightest addition of nitrogen the chlamydospore formation was suppresssd and the micro-conidial population increased.

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SOME ECOLOGICAL OBSERVATIONS ON *HOPEA PARVIFLORA* BEDD.

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Introduction

Hopea parviflora Bedd., the well known Iron Wood of Malabar, like many other dipterocarps *e.g.*, *Dipterocarpus indicus*, *Shorea robusta* and *Vateria indica*, is a tree of great economic importance. It yields a valuable timber which because of its strength and durability has been in considerable demand, being extensively used for house building, boat parts, as piles for bridges, and for railway sleepers. In view of its economic exploitability at the cost of some inferior species, at suitable sites plantations of this species have been raised to meet the demand. Thus, in many of the secondary forests of South Kanara district, *Hopea* prevails as an understorey crop, generally 35-40 years old. Though the details of silviculture and management of this versatile timber have been dealt with by Troup (1921) and Kadambi (1954), some additional data are brought forth in this paper for the South Kanara district (12°3′ – 13°59′ N – 74°32′ – 75°38′ E) laying emphasis on :

(*a*) Growth of the species in different forest types under natural conditions,

(*b*) Growth of the species under plantations,

(*c*) Associate disparity, successional status and natural regeneration of the species.

Studies are based on the floristic data gathered from Meganvalley, Naravi, Bantemale, Someshwar, Andar, Pilarkan, Yenmoor, Jarvattkadu, Jattkatmale, Mundajekap and Porkal reserve forests. Most of these places are situated at a lower elevation (less than 250 m above sea level) though some like Andar, Someshwar and Naravi in the ghats support the natural growth of *Hopea parviflora* at an altitude of 300-500 m. Rainfall data are not available for these places and are recorded below for the nearly localities only :

Locality	Mean annual rainfall (cm.)
Udipi (Pilarkan R. F.)	362·5
Puttur (Yenmoor R. F.)	376·5
Baindur (Meganvalley R. F.)	406·3
Beltangadi (Naravi R. F., Mundajekap R. F.)	452·2
Karkala (Andar, Jarvattkadu, Jattkatmale, Someshwar R. F).	495·5

Porkal and Bantemale reserves experience a high rainfall like Puttur.

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Natural growth

In South Kanara forests the natural growth of *Hopea parviflora* prevails in the semi-evergreen and evergreen forests. The species shows a wide range of associate disparity and its growth rate varies being better in the evergreen than in semi-evergreen type. It attains a height of over 25 m in the tropical wet evergreen forests of Meganvalley generally prevailing at about 400 m above sea level. At other sites also *i.e.*, Bantemale R. F., Naravi R. F., Andar R. F. and Someshwar R. F. it occurs almost at the same altitude. It has a more gregarious growth at Naravi and Andar than at other sites, but its height hardly exceeds 20 m. Here, it constitutes a single dominant forest—the *Hopea* consociation, with evergreen associates mainly. Above 500 m however, in these sites other species like *Poeciloneuron indicum, Palaquium ellipticum* and *Mesua ferrea* dominate forming mixed associations. At Pilarkan *Diospyros microphylla* and *Artocarpus hirsuta* predominate.

In the semi-evergreen type as at Yenmoor R. F., *Hopea* attains comparatively a low height (15 m) and has a scatered growth. It is associated here with an irregular assemblage of evergreen, semi-evergreen and deciduous components. The various associates of *Hopea parviflora* met with in the evergreen and semi-evergreen forests are given below for some selected sites.

| Associates | Evergreen type | | | Semi-evergreen type |
	Someshwar	Andar	Naravi	Yenmoor
Trees (I and II storey)				
Antiaris toxicaria	o	o	o	r
Artocarpus hirsuta	f	o	o	f
Calophyllum elatum	r	r	r	–
Canarium strictum	f	f	f	–
Carallia brachiata	o	r	r	f
Cinnamomum zeylanicum	f	f	f	o
Donella roxburghii	r	r	r	–
Elaeocarpus tuberculatus	r–o	r	r	–
Euphoria longana	f	f	o	–
Garcinia morella	r	r	r	–
Holigarna arnottiana	a	a	a	a
Hopea wightiana	r	r	r	r
Hydnocarpus laurifolius	r	r	r	r
Knema attenuata	f–a	f–a	f–a	o
Litsaea stocksii	r	r	r	–
Machilus macrantha	r	r	r	o
Olea dioica	f	f	f	f
Pithecolobium bigeminum	f	o	o	–
Schleichera oleosa	–	–	–	f
Terminalia tomentosa	r	–	r	f
Vateria indica	r	r	r–o	–

| Associates | Evergreen type | | | Semi-evergreen type |
	Someshwar	Andar	Naravi	Yenmoor
Small trees, shrubs, climbers (III and IV storey)				
Actinodaphne bourdillonii	f	f	f	—
Aporosa lindleyana	f	f	f	a
Calycopteris floribunda	r	r	o	f
Dichapetalum gelonoides	f	r–o	f	—
Entada scandens	r	r	r	—
Euonymus indicus	f	r	o	—
Flacourtia montana	f	f	o	—
Gnetum ula	f	f	f	f
Heynea trijuga	r	—	r	—
Humboldtia brunonis	r	o	o	o
Ixora brachiata	f	f	f	a
Mallotus philippensis	r	r	r	o–f

o = occasional ; f = frequent ; r = rare ; a = abundant

The soils investigated under these types represent lateritic group derived from metamorphic rocks, granitic gneiss, mica schists and ferruginous quartzites. The topography of the area under these forests is undulating. The soils are deep and moderately drained to well drained. Water table is fairly deep being approximately at a depth of 600–750 cm. from surface. The morphological description and analysis of soil profiles (A and B) is given in Table 1(a). It can be marked out that :

1. The soils exhibit wide variation in texture ; being sandy clay—sandy loams.
2. They contain a good proportion of gravel.
3. They exhibit variation in C. E. C., exchangeable metallic cations, pH and organic matter content in the different horizons of the profiles.
4. Exchangeable calcium is the dominant base in all the soils.

Plantations

Plantations of *Hopea parviflora* prevail in the secondary forests which may be moist deciduous or of semi-evergreen type. The growth of the species in height, girth, and bole size, is seen to be comparatively better in the semi-evergreen forests.

The plantation sites are located invariably at the foot of the ghats where the natural vegetation is of semi-evergreen and moist deciduous forests, the former type predominating. Average altitude of such places is 300 m and these receive a mean annual rainfall of about 350 cm. or more. At Jatkattmale reserve forest at the foot of the Someshwar ghat in the south east of the district, *Hopea* plantations of 1920–21 prevail. The trees have attained a height of about 10 m. and occur scattered all over in the forest, interspersed by deciduous, semi-evergreen or occasionally evergreen associates. Similar conditions prevail at Mundajekap (1926–28 plantations) at Nadigal and in Porkal reserve forest at Mannagundi in

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the north east of the distinct at the foot of Charmadi and Shiradi ghats. Here comparatively the tree has attained a better growth averaging to 12 m. in height and occurs gregariously.

The natural vegetation in all the sites where plantations are met with is a *Xylia-Terminalia* mixed forest whose associates vary depending upon the locality factors of the sites. In general following species are met with.

| Associates | *Terminalia-Xylia* mixed forest | |
	Jatkattmale	Mundajekap
Top storey		
Adina cordifolia	o	o
Alstonia scholaris	r	r
Careya arborea	r	o
Caryota urens	r	r
Ervatamia heyneana	f	f
Fagara budrunga	r	o
Ficus lacor	r	r
Holigarna arnottiana	a	a
Knema attenuata	f	ι
Lagerstroemia lanceolata	f	:
Lannea coromandelica	o	o
Lophopetalum wightianum	r	r
Macaranga peltata	r	o
Machilus macrantha	o	r
Madhuca indica	r	o
Olea dioica	f	f
Schleichera oleosa	o	o
Strychnos nux-vomica	f	f–a
Syzygium cumini	r	r
Terminalia bellerica	r	r
T. paniculata	f–a	f–a
T. tomentosa	f	f
Xylia xylocarpa	a	a
Understorey		
Aporosa lindleyana	a	a
Calycopteris floribunda	f	f
Feronia limonia	o	o
Gnetum ula	f	o
Ixora brachiata	a	a
Mallotus philippensis	r	o

TABLE 1(a)

Analysis of soil samples from natural sites

Depth Inches	Mechanical composition (-2 mm.)				pH	CaCO₃ %	Organic matter %	C.E.C. m.e. %	Total exchangeable metallic cations m.e. %	Exchangeable calcium m.e. %	Morphological details
	Coarse sand %	Fine sand %	Silt %	Clay %							
Profile A (Yenmoor R. F.)											
0–2	49·9	0·9	9·3	39·9	5·8	nil	4·07	18·53	12·84	9·65	Dark reddish brown sandy clay, with hard quartzite particles, moderate fine granular structure, sticky intimate organic matter, roots very common.
2–10	31·4	4·4	15·8	48·4	5·7	nil	3·53	14·22	8·08	6·32	Reddish brown clay, structureless, smooth and compact, very sticky, firm and hard, some organic matter, easy root penetration.
10–28	16·4	4·7	21·1	57·8	6·0	nil	0·60	10·36	6·85	5·48	Reddish brown clay with some yellowish mottlings, gravel pieces and hard quartzite particles, massive, sticky, little organic matter, roots penetrating.
28–39	16·0	5·6	15·3	63·1	6·2	nil	0·42	11·15	8·96	6·80	Yellowish clay with reddish brown gravel pieces and quartz particles, massive, sticky, firm and hard, no pores noted.
Profile B (Someshwar R. F.)											
0–2	33·3	44·4	16·1	6·2	5·2	nil	7·86	14·92	8·43	6·87	Dark grey sandy loam with weak fine granular structure, nonsticky, very friable, loose, porous, good humus content and many roots.
2–8	29·5	41·6	19·2	9·7	5·0	nil	5·43	13·63	6·56	5·20	Yellowish grey sandy loam, nonsticky, loose and porous, organic matter and roots, easy root penetration.
8–19	27·5	36·3	19·5	16·7	5·1	nil	3·13	12·87	7·21	5·48	Yellowish sandy loam, porous, contains organic matter and a few roots.
19–37	25·6	37·8	20·3	16·3	5·2	nil	2·60	9·54	5·80	4·92	Yellowish-red sandy loam, porous, contains a few quartz fragments, a little organic matter.
37–48	29·2	35·7	18·1	17·0	5·2	nil	0·75	8·57	5·65	4·78	Red sandy loam, porous, a few quartz fragments and soft iron concretions.

TABLE 1(b)

Analysis of soil samples from plantations

Depth Inches	Mechanical composition (-2 mm.)				pH	CaCO₃ %	Organic matter %	C.E.C. m.e.%	Total exchangeable metallic cations m.e.%	Exchangeable calcium m.e.%	Morphological details
	Coarse sand %	Fine sand %	Silt %	Clay %							

Profile C (Jarvattkadu R. F.)

Depth	Coarse	Fine	Silt	Clay	pH	CaCO₃	OM	C.E.C.	Total	Ex. Ca	Morphological details
0–3	27·8	48·8	17·9	5·5	5·6	nil	8·33	18·32	13·00	11·88	Dark grey fine loamy sand, rich in humus, porous with good crumb structure, nonsticky, many roots.
3–10	31·1	39·4	18·6	10·9	5·7	nil	4·93	8·72	5·05	4·15	Greyish brown sandy loam, nonsticky, loose and porous with iron concretions, a little organic matter, a few roots.
10–22	26·3	42·8	14·8	16·1	5·6	nil	2·62	4·55	2·80	2·12	Dark red sandy loam, nonsticky, loose and porous, several iron concretions, a little organic matter, a few roots.
22–42	24·6	34·1	20·5	20·8	5·2	nil	0·61	5·42	3·16	2·26	Red sandy or sandy clay loam, compact and structureless, many iron concretions.

Profile D (Jattkatmale R. F.)

Depth	Coarse	Fine	Silt	Clay	pH	CaCO₃	OM	C.E.C.	Total	Ex. Ca	Morphological details
0–3	46·7	24·0	19·9	9·4	5·4	nil	11·93	17·63	9·97	6·38	Dark grey sandy loam, rich in humus, well granulated, porous, and spongy, nonsticky, many roots.
3–8½	37·6	32·5	16·6	13·3	5·6	nil	4·17	11·33	7·56	5·55	Greyish brown sandy loam, nonsticky, structureless, loose and porous, some organic matter and roots.
8½–21	31·4	35·2	18·8	14·6	5·4	nil	2·86	3·88	2·27	1·82	Dark red sandy loam, nonsticky, structureless, loose, porous, with friable concretions, a little organic matter.
21–48	49·6	38·5	9·8	2·1	5·0	nil	0·30	3·52	2·10	1·84	Yellowish sand, soft friable particles from disintegrating rock very common, comparatively compact.

The soil profiles investigated under these secondary forests represent brown lateritic soils. The topography of the area is undulating to rolling. The soils are deep and well drained. Their Morphology and analysis (Profiles C and D) is given in Table I(b) which shows that :

1. The soils are sandy loam in texture.
2. Their cation exchange capacity, organic matter content and exchangeable metalic cations, varies being generally highest in surface horizon.
3. The dominant exchange base is calcium as in the soils from natural sites.
4. Unlike natural forest sites, the pH in these soils increases in the horizon next to the surface one, thereafter decreasing with depth.

Natural regeneration

It has been observed that natural regeneration of the species is better in the semi-evergreen forests than in the wet evergreen type. In the moist deciduous type, the regeneration of the species is poor unless the forest has some evergreen components as in the *Xylia* mixed type. In general, *Xylia xylocarpa* is seen to regenerate better than this species. The ground layer has the following composition in the above forests.

Species	Someshwar	Andar	Naravi	Yenmoor
Actinodaphne sp.	r	r	r	r
Artocarpus hirsuta	—	r	—	o
Canthium angustifolium	r	r	r	o
Carallia brachiata	r	r	—	r
Cinnamomum zeylanicum	o	o	o	f
Caryota urens	—	—	—	r
Dracaena sp.	r	o	o	—
Garcinia sp.	r	r	r	—
Geophila reniformis	r	r	r	—
Gymnopteris sp.	o	o	o	—
Hedychium sp.	o	—	—	—
Hedyotis nitida	—	—	o	r–o
Holigarna arnottiana	o	o	o	o
Hopea parviflora	o	r	r	f
Ixora brachiata	r	r	r	r
I. nigricans	—	r	—	—
Knema attenuata	r	r	r	o
Leea indica	o	r	o	o
Litsaea sp.	—	—	r	r
Macaranga peltata	—	—	—	r–o
Memecylon sp.	o	—	r	—
Nothopegia colebrookiana	o	o	f	—

Species	Someshwar	Andar	Naravi	Yenmoor
Ophiorrhiza sp.	–	r	r	–
Piper nigrum	–	r	r	–
Psychotria dalzellii	o	o	o	o
P. truncata	f	f	f	o
Pterospermum sp.	–	r	–	–
Terminalia sp.	–	–	–	o
Xylia xylocarpa	–	–	–	f

Successional status

Like the *Xylia* mixed types, *Hopea* forests have a transitional status between the moist deciduous/semi-evergreen and evergreen types, though the species is better spread than *Xylia* in the evergreen forests. Generally, it is seen to occur gregariously in patches in the semi-evergreen and evergreen types and with *Xylia xylocarpa*, its successional trends can be indicated as follows :

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                        (climax)
                ↗     Evergreen      ↖
    Hopea mixed ↙ ↖   ↑   ↗ ↘ Xylia mixed
            ↖   Semi-evergreen   ↗
                    ↑
               ↘ Moist deciduous ↗
```
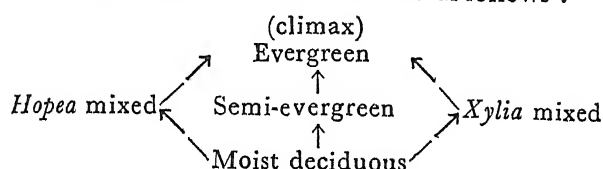
Conclusions

1. The above data on the natural occurrence of *Hopea parviflora* as well as the data given for some other sites by Bourdillon (1904), Alvares (1931), Kadambi (1941, 1950, 1954) and Chandrasekran (1962) suggest that *Hopea* forests attain either a climax status or a transitional status leading to the climax type in these ghat areas under humid tropical conditions.

2. The above is not true so for as plantations are concerned. In these secondary forests, *Hopea* prevails in the moist deciduous and semi-evergreen types attaining better growth in the latter. Generally, in all these forests, a canopy of deciduous components like *Terminalia tomentosa*, *T. paniculata* with *Xylia xylocarpa* prevails.

3. Thus the species shows a great deal of associate disparity under natural conditions. It grows on one hand with typical wet evergreen components like *Poeciloneuron indicum*, *Palaquium ellipticum*, and *Dipterocarpus indicus* which are associates of the climatic climax type while in the secondary forests in plantations invariably, it has moist deciduous components like *Terminalia* spp., with *Xylia xylocarpa*. At places it may even be associated with *Pterocarpus marsupium* (Porkal R. F.). Generally it prevails in all these forests as an understorey species while in the natural forests it is a top storey component.

4. The species in early stages requires a sparse cover and is a light demander. A loose canopy helps its growth, and for that reason the plantations thrive well at sites supporting a miscellaneous assemblage of species. Abundant natural regeneration of the species is invariably seen in cleared sites where trees have been felled (Jarvattkadu R. F.).

5. Soil characteristics are more or less similar in the natural and plantation sites.

Acknowledgements

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STUDIES ON SOME SOILS OF HUMID TROPICS

By

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Introduction

The effect of the underlying rock and nature of soil in relation to vegetation has long been emphasized. Troup (1921) gave a number of examples to show that forest vegetation of India is related to geological and soil conditions. Concentrating on the Humid Tropics of Andamans, Chengappa (1934) concluded that the evergreen forests occur on non-calcareous micaceous sandstones, while the semi-evergreen *Dipterocarpus* type was found mainly on conglomerate and hard metamorphic substratum. A similar type of relationship between forest communities and soil types has been brought out for Assam, where most of the work on the soils has been carried out by Medlicot (1855); Raychoudhry (1941); Raychoudhry and Mukerji (1941); Coulsen (1942); Seth and Yadav (1960); and others. It has been established that distinct types of forest vegetation, namely the **Hollock** (*Terminalia myriocarpa*) community in the zones of Brahamputra series and the **Hollong** (*Dipterocarpus macrocarpus*) community occur in two distinct types of soils based on their pH and moisture content requirements. *Terminalia myriocarpa* is able to thrive on soils of low acidity and of high moisture contents whereas the *Dipterocarp* type (Hollong) requires a well drained sandy/loam soil with higher pH status. Again it has been observed that species like *Vatica lanceofolia, Calamus* sp., *Pinanga gracilis*, growing in low lying areas with high moisture contents while *Girardinia heterophylla* and *Calamus leptospadix* usually occur on well drained soil at the foot of the hills, and *Meliosma simplicifolia* occurs in sandy situations.

Dealing with the vegetation of Burma, Stamp (1925) found a very interesting correlation between geology and vegetation types. He pointed out the occurrence of entirely different types of vegetation under similar conditions of climate.

A similar type of work for peninsular India has been carried out by Champion (1920); Vahid (1927); Puri (1956); Bhatia; (1954); Arora (1960); Seth and Yadav (1960); and others. But very little is known regarding the relationship of soils and vegetation types of the humid tropics.

Classification of soils

Working in the districts of Belgaum, Shimoga and Chikmagalur of Mysore State, three different soil types have been recognised *i.e.,*

1. Black soil; 2. Red soil; and 3. Laterite soil.

Black soil is derived from granite, gneiss or basalt and bears a deciduous type of vegetation of Teak or Bamboo or scrubs of *Ixora, Gymnosporia, Randia, Dodonea,* etc. The soil may be formed in-situ or more commonly is alluvial in nature. Black soil is heavy in texture and the clay content varies from 40–60%. The soil is slightly acidic to neutral in reaction. Prevalence of montmorillorite type of clay mineral accounts for higher cation exchange capacity. Calcium dominates the base complex. The silica/sesquioxde ratio is generally more than 3. Robinson (1949) reported that the colour of the soils largely depend on drainage.

Present address : Survey of Medical Plants, P. O. Gurukul Kangri.
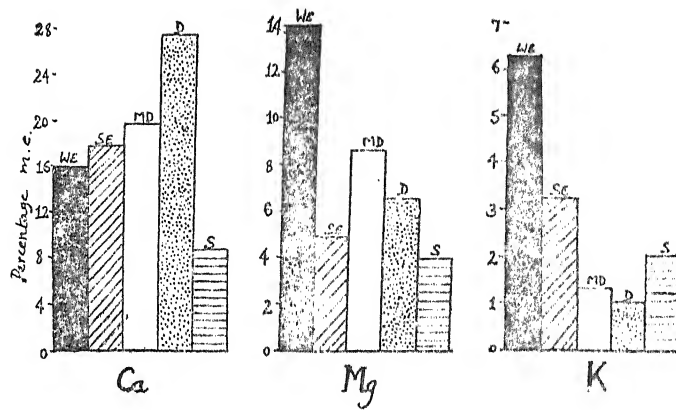
PLATE I.

Histograms representing Calcium, Magnesium and Potassium in
miliequivalents of soils in different vegetation types at surface layer.
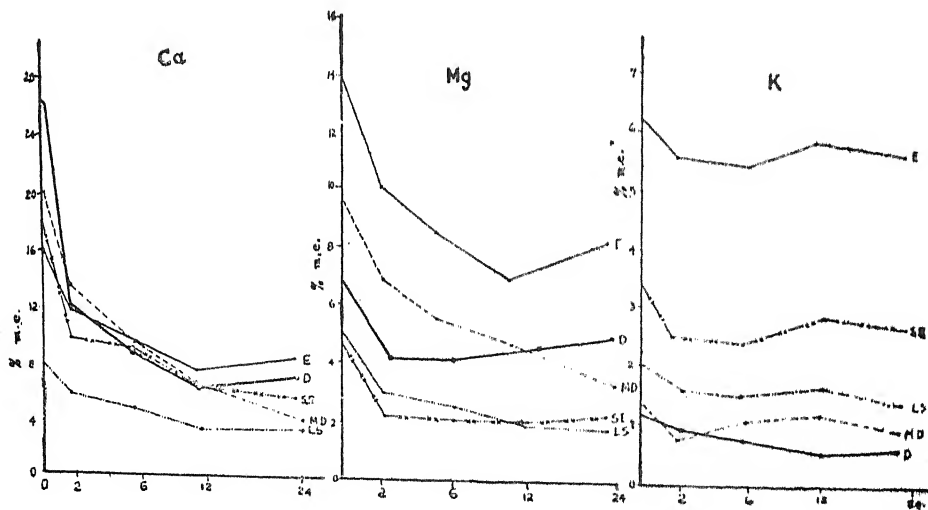
PLATE II.

Graph showing Calcuim, Magnesium and Potassium in miliequvalents of soils in different
vegetation types at different depths.

m.e. miliequvalents ; W.E. and E.—Wet-evergreen forests ; S. E.—Semi-evergreen forests;
M.D.—Moist-deciduous forests ; D.—Dry-deciduous forests ; L.S. and S.—Lateritic scrubs.

Red soil, which occupy the largest area, supports a luxurient vegetation of evergreen species *e.g.*, *Dipterocarpus, Diospyros, Calophyllum, Cinnamomum, Poeciloneu-ron, Palaquim, Mesua, Hopea, Olea, Myristica*, etc. The soil is formed from the decomposition of granites, gneiss and schists in-situ. Predominance of iron oxide determines its colour. Red soil is sandy loam to clayey loam in texture and the depth varies with the topography of the locality where it is found. In general the soil is thin on the uplands and deep in low lying areas. The predomenant clay minerals are kaolinate which impart a lower cation exchange capacity to the soil. Base status is not very high. Kankar or nodules of calcium carbonate are absent.

Laterite soil bears semi-evergreen types of vegetation, dominated by *Xylia xylocarpa* and scrubs of *Canthium, Olea, Syzygium*, etc. Laterite soil may be sedimentary or transported and is characterised by the presence of indulated, honey-ombed mass which is developed from the separation of nodules of Iron oxides cand their gradual cementation. Clay complex is dominated by the hydrous oxide of Iron and Alluminium. The soil is poor in all the plant nutrients.

Material and Methods

Samples of the abovementioned different soil types were collected and chemically analysed, profile wise for their base status *i.e.*, exchangeable Calcium, M.gnesium and Potassium contents. The methods of Piper (1944) were followed for this study *i.e.*, leaching the soil by N and 2N Ammonium chloride and taking :

1. Oxalic acid method for Calcium
2. Sodium citrate method for Magnesium ; and
3. Cobalt nitrate method for Potassium.

Results

The 12 profiles analysed for their chemical constituents, comprise of five from evergreen forest soils (3 wet-evergreen and 2 semi-evergreen) ; five from deciduous forest soils ·(2 moist-deciduous and 3 dry-deciduous) ; and two from scrub forest soils. The data is tabulated in Tables I–III.

TABLE I

Showing exchangeable Calcium of different profiles at different depths

Vegetation type	Community	Exchangeable calcium in m.e. at				
		0″	2″	6″	12″	24″
Evergreen	*Poeciloneuron-Mesua*	14·2	11·24	9·56	8·7	8·3
	Hopea-Olea-Myristica	16·3	12·24	10·3	8·5	7·3
		16·5	11·5	9·6	7·8	9·25
Semi-evergreen	*Xylia-Olea-Tabernemon-tana*	18·44	12·9	11·3	9·3	9·6
		18·5	10·4	9·8	7·6	6·2
Moist-deciduous	*Teak-Terminalia-Emblica*	21·23	11·4	11·05	10·2	6·72
		20·2	13·5	10·6	7·8	4·66
Dry-deciduous	*Teak-Anogeissus*	26·4	12·5	9·9	7·5	7·08
		24·8	13·7	10·6	8·4	8·88
		28·5	11·8	9·8	7·9	8·3
Laterite scrubs	*Canthium-Olea Syzygium*	7·8	6·4	5·6	4·2	4·7
		6·6	6·06	5·6	4·59	4·92

TABLE II
Showing exchangeable Magnesium in different profiles at different depths

Vegetation type	Community	Exchangeable calcium in m.e. at				
		0″	2″	6″	12″	24″
Evergreen	Poeciloneuron-Mesua	14·5	10·6	8·5	6·3	8·1
	Hopea-Olea-Mryistica	10·5	8·6	9·4	10·1	11·1
		10·2	6·5	7·5	8·2	8·7
Semi-evergreen	Xylia-Olea-Tabernemontana	5·6	3·3	2·8	3·4	3·2
		4·83	1·91	2·25	2·48	3·35
Moist-deciduous	Teak-Terminalia-Emblica	13·2	10·5	9·5	7·8	10·2
		9·4	6·94	5·6	4·52	2·15
Dry-deciduous	Teak-Anogeissus	6·97	3·83	3·8	4·35	4·5
		7·8	4·5	3·46	3·92	4·2
		9·2	5·3	4·8	4·12	3·85
Laterite scrubs	Canthium-Oleo-Syzygium	4·75	3·3	2·8	2·15	2·5
		2·12	1·79	1·75	1·9	2·00

TABLE III

Showing exchangeable Potassium in different profiles at different depths.

Vegetation type	Community	Exchangeable calcium in m.e. at				
		0″	2″	6″	12″	24″
Evergreen	Poeciloneuron-Mesua	6·2	5·5	5·3	5·7	4·5
	Hopea-Olea-Myristica	4·5	3·75	4·5	5·5	3·75
		5·1	4·38	4·32	4·8	3·9
Semi-evergreen	Xylia-Olea-Tabernemontana	4·8	2·7	2·23	2·32	2·1
		3·3	2·5	2·45	2·7	2·48
Moist-deciduous	Teak-Terminalia-Emblica	4·7	3·7	3·66	3·46	3·45
		1·06	0·75	3·20	1·5	0·95
Dry-deciduous	Teak-Anogeissus	1·15	0·85	0·74	0·55	0·62
		1·32	0·95	0·76	0·65	0·53
		1·48	1·02	0·83	0·62	0·68
Laterite scurbs	Canthium-Olea-Syzygium	2·3	1·6	1·5	1·9	1·7
		1·9	1·2	1·3	1·7	1·8

Discussion

Large amounts of nutrients taken up by luxurient vegetation are constantly returned to the soil, chiefly through leaf and other fallen plant parts (litter). Due to favourable environmental conditions, these plant-remains are rapidly decomposed and the nutrients are released. That is why the surface layer of most of the soil profiles analysed is considerable rich in exchangeable bases and contains 1·5–3·5 times, sometimes even more, as much exchangeable bases as the lower layers. The data obtained reveals that the 2″ and 12″ deep layers are poorer in these

bases due to leaching while the 24" deep layer being less leached is richer, the amount sometimes being of the same order as those of the surface layer. Similar distribution of bases has been reported by Jones (1955) from the rain forest soil profiles of Southern Nigeria.

In the soils of the Humid Tropics region, the most abundant exchangeable cations are firstly Hydrogen and Calcium, secondly Magnesium, and thirdly Potassium and Sodium (Lyan and Buckman, 1947). In the soil profiles analysed, the exchangeable Calcium contents are upto four times as much as the exchangeable Magnesium content and upto 20 times as much as exchangeable Potassium.

It is interesting to note that the amount of each cation. Calcium is highest in the dry-deciduous forest soils, while it is slightly lower in the moist-deciduous and becomes lowest in wet-evergreen through semi-evergreen.

The difference seems to be due to the higher altitude of evergreen forests, whose soils are considerably leached as result of high rainfall (Agumbe, 300 inches per year). On the other hand deciduous and semi-evergreen types being less leached, (Londa, 60 ; Sutgatti, 45 inches), are richer in exchangeable Calcium. Another important feature contributing to this varying Calcium status would be foliar composition of the vegetation. The deciduous trees are richer in foliar Calcium than the evergreen trees (Ahuja, 1961, 1964).

On the other hand in the case of exchangeable Potassium, reverse is true *i.e.*, the amount is lowest in dry-deciduous type and increases through moist-deciduous and semi-evergreen to wet-evergreen type.

Although the behaviour of Magnesium and Calcium in soils is similar (Lutz and Chandler, 1959 ; Lyan and Buckman, 1947), in the soil profiles examined, the exchangeable magnesium is found to be indifferent to vegetation types.

Laterite profiles supporting sparse vegetation (*Olea dioica, Canthium* sp., *Syzygium* sp., *Ixora* sp., etc.) are poor in all three bases. Soil is shallow and rock is exposed at most of the places as most of the soil is leached out due to heavy rainfall.

Summary

The effect of the underlying rock and soil in relation to vegetation has long been emphasized. Soil samples of different soil types were collected and chemically analysed profile wise for their base status. The method of Piper (1944) was followed. Twelve profiles have been taken for the present study.

Acknowledgment

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UTILIZATION OF OLIGOSACCHARIDES BY SOME ANTHRACNOSE FUNGI

By

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Anthracnose diseases of mango, papaya, guava and banana are of considerable importance and have received the attention of various investigators. So far, some nutritional studies on the causal organisms have been done ; but a detailed work on the utilization of oligosaccharides by these fungi has not been undertaken.

Modern paper chromatographic techniques have rendered it possible to derive valuable information regarding the pathway of utilization of carbohydrates by fungi. In the present study regular chromatographic analyses coupled with dry weight studies of the mycelial mats have been employed in order to understand the comparative efficiency of four anthracnose fungi in utilizing some oligosaccharides.

Materials and Methods

Single-spore cultures of *Colletotrichum gloeosporioides* Penz., *Colletotrichum papayae* P. Henn., *Gloeosporium psidii* Delacr. and *Gloeosporium musarum* Cooke *et* Mass. isolated from diseased fruits of mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and banana (*Musa paradisiaca* L.) respectively were employed. The basal medium consisted of KNO_3, 3·5 g ; KH_2PO_4, 1·75 g ; $MgSO_4 \cdot 7 H_2O$, 0·75 g ; and distilled water, 1000 ml. To this medium each oligosaccharide was added singly in such a quantity so as to furnish 4 g of carbon per litre. Eight oligosaccharides, *viz.*, sucrose, maltose, cellobiose, trehalose, lactose, melibiose, raffinose and melezitose were used. All the chemicals employed were of guaranteed purity. On the basis of previous investigations the initial pH of the medium was adjusted to 5·8 in all cases. 25 ml of the medium was poured in each of the 150 ml Pyrex Erlenmeyer flasks. The flasks containing media were then subjected to fractional sterilization by 30 minutes' steaming for three successive days. The flasks were then inoculated with mycelial bits of approximately equal size of ten day old culture of the respective organisms and were incubated at $25 \pm 1°C$. The experiments were conducted in triplicate sets. Each day 0·005 ml of the medium from a flask belonging to a particular set was analysed by the circular paper chromatographic technique used by Ranjan *et al.* (1955). In case of lactose, melibiose and raffinose the chromatograms were run in *n*–butanol-pyridine-water (45 : 25 : 40) ; whereas, the solvent used for the rest of the sugars was *n*–butanol-acetic acid-water (4 : 1 : 5, upper layer). After drying the chromatograms were sprayed with aniline-diphenylamine phosphate reagent (5 vols. 4% aniline, 5 vols. 4% diphenylamine and 1 vol. orthophosphoric acid ; Buchan and Savage, 1952.) The bands were developed by heating the chromatograms in electric oven at 110°C for 90 seconds. Trehalose, which does not give band with the above reagent, was detected by spraying the chromatograms with ammonical silver nitrate solution and subsequently heating them at 100°C for 2–3 minutes. In each case the mycelial mats were harvested after 5, 10 and 15 days of incubation. Previously dried and weighed Whatman's No. 42 filter papers were used for this purpose. They were dried to constant weight in an electric oven at 60°–62°C and were weighed again after cooling in a desiccator. The average dry weight of mycelium was taken as the criterion for growth.

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Results

The results obtained have been summarised in Tables 1 and 2.

TABLE 1

Showing the presence (in days) of various sugars in the culture medium during the utilization of different oligosaccharides by the four anthracnose fungi

Sugar	Organism			
	C. gloeosporioides	*C. papayae*	*G. psidii*	*G. musarum*
Sucrose				
Sucrose	0–5	0–3	0–3	0–3
Glucose	3–6	2–5	3–5	2–8
Fructose	3–9	3–8	3–7	2–13
Oligosaccharide I (Rf 0·27)	3–6	2–5	3–5	2–4
Oligosaccharide II (Rf 0·2)	4–5	–	4	3–4
Maltose				
Maltose	0–8	0–6	0–5	0–5
Glucose	6–9	–	–	4–8
Oligosaccharide I (Rf 0·18)	4–8	3–6	3–5	3–6
Oligosaccharide II (Rf 0·1)	6–8	–	5	–
Cellobiose				
Cellobiose	0–7	0–8	0–6	0–9
Glucose	5–8	5–6	5–6	5–10
Oligosaccharide I (Rf 0·16)	5–7	5–7	–	5–9
Oligosaccharide II (Rf 0·11)	5–7	5–7	–	5–8
Trehalose				
Trehalose	0–8	0–9	0–7	0–7
Glucose	5–9	6–11	5–8	2–10
Lactose				
Lactose	0–15	0–15	0–13	0–15
Melibiose				
Melibiose	0–5	0–4	0–4	0–4
Galactose	3–8	2–5	3–4	2–15
Glucose	–	2–4	–	2–10
Raffinose				
Raffinose	0–7	0–7	0–6	0–6
Melibiose	3–6	–	–	–
Galactose	4–7	3–9	4–6	4–12
Glucose	–	3–4	–	4–5
Fructose	–	3–7	4	4–11
Oligosaccharide I (Rf 0·16)	–	2–3	–	–
Melezitose				
Melezitose	0–10	0–8	0–5	0–15

TABLE 2

Showing the dry weights (in mg) of mycelium of the four anthracnose fungi on different oligosaccharides

Oligosaccharide	Days of incuba-tion	Organism			
		C. gloeosporioides	*C. papayae*	*G. psidii*	*G. musarum*
Sucrose	5	33·2	36·8	42·5	15·5
	10	101·6	82·0	84·0	47·2
	15	96·4	80·2	87·0	74·2
Maltose	5	25·3	25·6	44·3	20·0
	10	96·8	84·2	109·4	95·6
	15	83·0	84·0	88·2	85·2
Cellobiose	5	15·7	23·7	29·2	19·2
	10	77·4	73·7	85·7	61·3
	15	81·9	87·8	80·1	73·2
Trehalose	5	24·2	29·8	37·8	25·9
	10	103·9	81·2	90·0	73·2
	15	96·4	98·7	83·8	96·0
Lactose	5	16·3	21·5	20·0	19·5
	10	48·6	45·0	49·0	37·8
	15	78·0	77·0	94·5	61·9
Melibiose	5	33·8	37·5	41·9	15·3
	10	70·3	68·3	80·8	28·3
	15	67·1	56·3	68·1	45·4
Raffinose	5	39·6	37·2	35·4	21·2
	10	73·0	83·6	75·4	66·0
	15	65·1	78·6	66·9	66·1
Melezitose	5	31·2	36·3	31·6	10·5
	10	98·1	122·0	101·4	25·3
	15	109·8	102·5	91·0	41·9

Discussion and Conclusions

Whether it is necessary for an oligosaccharide to be first hydrolysed to the component monosaccharide units prior to utilization by a fungus was a controversial question for the earlier workers in the field of fungal nutrition. Recent advancement in chromatographic technique has made it possible to detect various intermediate products in the culture medium, and thus, has rendered great help in following the path of utilization of oligosaccharides. Although it has now been shown that generally fungi utilize oligosaccharides after hydrolysis, there are some records of direct utilization. Mandels (1954), for instance, reported that the spores of *Myrothecium verrucaria* could utilize sucrose directly.

It would be seen from the results of the present study that the media containing these oligosaccharides did not show any breakdown product after sterilization ('zero' day of incubation). The appearance of monosaccharides in these

media after the fungi were inoculated and allowed to incubate, therefore, was due to the enzymatic activity of these organisms.

Among the disaccharides, sucrose and maltose were readily metabolized and the pathway of utilization was a hydrolytic one. In maltose medium used by *C. papayae* and *G. psidii* no glucose could be detected ; but the appearance of synthetic oligosaccharide was an evidence of the breakdown of this sugar. Non-appearance of glucose in those cases was obviously due to its simultaneous utilization. *G. psidii* failed to synthesize any oligosaccharide in cellobiose medium and in this respect differed from the other three fungi, each of which produced two synthetic oligosaccharides. During the utilization of melibiose by *C. papayae* and *G. musarum* both the hydrolytic products, *viz.*, glucose and galactose, made their appearance in the culture medium, whereas in case of *C. gloeosporioides* and *G. psidii* only galactose could be detected. This indicates that the latter organisms had a preference for glucose over galactose, and that the rate of assimilation of glucose was rapid. The trisaccharide, raffinose, when attacked at α–linkage by an enzyme breaks up into galactose and sucrose ; whereas when the cleavage takes place at β–linkage, fructose and melibiose are formed. From the results of the present investigation it would be seen that during the utilization of raffinose by *C. papayae*, *G. psidii* and *G. musarum* none of the two intermediate disaccharides, *viz.*, sucrose and melibiose, could be detected. Obviously, this was due to comparatively slower rate of liberation of the disaccharide concerned and rapid rate of its breakdown. It is also clear from the results of sucrose and melibiose utilization that the rate of breakdown of these sugars was fast. Appearance of melibiose during the utilization of raffinose by *C. gloeosporioides* indicates that in this case the β–linkage was attacked first. Non-appearance of glucose and fructose in some cases was also apparently due to simultaneous utilization.

Although appearance of the hydrolytic product(s) of an oligosaccharide indicates indirect utilization, it is not necessary that non-appearance would invariably mean direct utilization. In those cases where the rate of breakdown of the oligosaccharide is slow and the rate of utilization of the resultant monosaccharide(s) is rapid, there is every likelihood that the latter sugar(s) would not be detectable. This possibility has to be taken into account while considering the mode of utilization of lactose by the present fungi. However, no process other than direct utilization could be visualized, in case of the rapid consumption of melezitose (which persisted in the medium for only 5 days) by *G. psidii*, without the appearance of any hydrolytic product.

It would be evident from the results that the efficiency with which an oligosaccharide is utilized by fungi is to a great extent dependent on its structural configuration. Lactose and melibiose showed striking difference in their rates of utilization by these fungi, although both of these disaccharides contain the same monosaccharide units (*i.e.*, glucose and galactose).

It is apparent that the present organisms except *G. musarum* showed a close similarity in their rates of utilization of different oligosaccharides. *G. musarum* differed markedly from the other fungi in its comparatively slow rate of assimilation of the hydrolytic products. It is interesting to note that the rate of breakdown of oligosaccharides by this organism was fast. This is an indication that the efficiency of glycosidase activity shown by *G. musarum* was in no way lesser than that exhibited by the other organisms, although the kinase activity was poorer.

In recent years, the discovery of the mechanism of transglycosidation (or transglycosylation) has brought about a drastic change in our concept of hydrolysis

of higher sugars. This process involves the formation of a sugar-enzyme complex and subsequent transfer of the sugar part from the complex to a suitable acceptor. When the sugar fraction is transferred to water, it is a case of simple hydrolysis; when it is transferred to a molecule of the original sugar a higher oligosaccharide is formed. Investigations carried out by many workers including Wallenfels (1951), Bealing and Bacon (1951), Pazur and French (1952), Albon *et al.* (1953), Buston and Jabbar (1954), Tandon and Bilgrami (1958), Wilson and Lilly (1958), Agnihotri (1962) and Bilgrami (1964) have demonstrated the production of transglycosidases by fungi. In the present investigation, appearance of synthetic oligosaccharides in the culture media containing sucrose, maltose and cellobiose evidenced the activity of trans- α and trans- β-glycosidases produced by the four anthracnose fungi. *G. psidii* differed from the rest of the organisms included in the present study as it did not synthesize any oligosaccharide in a medium containing cellobiose. In a raffinose medium only *G. papayae* exhibited the formation of synthetic oligosaccharide.

It would be evident from the dry weight studies of the mycelial mats of these fungi that when the rate of utilization of a particular sugar was comparatively slow, the dry weight showed an increase upto the end of the final incubation period (15 days). On the other hand, in those cases where the utilization of sugar was rapid the maximum dry weight was attained after 10 days of incubation and at the end of final incubation (15 days) the weight either recorded a fall or it remained more or less constant. The efficiency with which an organism utilized an oligosaccharide, however, could not always be correlated with the final amount of growth (mycelial dry weight) produced on that particular sugar.

Summary

Utilization of eight oligosaccharides, *viz.*, sucrose, maltose, cellobiose, trehalose, lactose, melibiose, melezitose and raffinose, by *Colletotrichum gloeosporioides*, *C. papayae*, *Gloeosporium psidii* and *G. musarum* isolated from diseased fruits of mango, papaya, guava and banana respectively, was studied chromatographically. Hydrolytic products of all the oligosaccharides, except lactose and melezitose, could be detected in the medium during their utilization. *G. musarum* took comparatively long time in utilizing the hydrolytic products of these oligosaccharides although the rate of hydrolysis was fast. Formation of synthetic oligosaccharides was recorded in media containing sucrose, maltose and cellobiose. During the utilization of raffinose by *Colletotrichum papayae* an oligosaccharide was synthesized. Dry weight of mycelial mats showed a rise upto the end of incubation period of 15 days, when the utilization of oligosaccharides or their hydrolytic products was slow. In other cases, it recorded a fall after 10 days or tended to become constant.

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PHYSIOLOGICAL-ECOLOGY OF *XANTHIUM STRUMARIUM* L. III. EFFECT OF EDAPHIC AND BIOTIC FACTORS ON GROWTH AND DISTRIBUTION*

By

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The first paper of this series (Kaul 1965*a*) is concerned with the seasonal morphological variants of the species and with its range and distribution.

The second paper (Kaul 1965*b*) seeks to analyse the various physiological and ecological aspects, involved in the problems centering around the motile phase of the life cycle *i.e.*, the seed output, seed longevity, type and depth of dormancy, seed viability and seed germination in relation to its growth and distribution in space and time.

This, the third paper in the series, relates to the effects of edaphic and biotic factors on growth and occurrence of the species in India.

Edaphic factors

Xanthium strumarium L. seems to be very much indifferent to the edaphic factors since it grows in almost all the soil types of the world ; irrespective of their parent material, origin and nature ; in addition to the multifarious types of habitats and substrata as described by Kaul, (1965*a*). It is very much prevalent in the soils of Africa, Australia, Ceylon, China, Germany and India, where it has been causing a great menace at one time or another, or is doing so at present.

In India it grows in all the soil types that have been recognised by Raychaudhuri (1943). It grows in the red soils of Madras, Mysore, Southeast Bombay, east of Hyderabad, Madhya Pradesh, Orissa and Chota Nagpur in south ; and Bihar, Bengal, Mirzapur, Jhansi and Hamirpur districts of Uttar Pradesh in the north ; in the lateritic soils of Mysore, Travancore, Central India, the eastern Ghat Region of Orissa, south Bombay and parts of Assam ; in the black soils of Bombay, Kathiawad, Berar, the western parts of Madhya Pradesh, Hyderabad and some parts of Madras ; in the alluvial soils of Punjab, Uttar Pradesh, Bihar, Bengal, parts of Assam and Orissa, and in the coastal areas of southern India including the deltaic areas on the mouths of rivers ; in desert soils of Rajputana and Sind ; in saline soils of Bombay, Madras and other places of sea coast ; besides in marshy soils of Travancore, Cochin, Sunderbans and south-east coast of Madras.

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Characters of soils supporting large stands of X. strumarium L. in different parts of the country

S. No.	Locality	Surface	Consistence	Cementation	Structure	Compactness	Texture	Colour	Pore Space %	Stoniness	pH	CO_3	NO_3	Base deficiency	Reductivity	Organic matter	Total soluble salts
1	Varanasi	Loose friable	Non-sticky	Weakly cemented	Fine massive platy	Not compact	Sandy loam clay	Light brown grey	42	No stones	7·5	1	2	3	1	3	$5·4×10^3$
2	Bhelupur Varanasi	,,	,,	,,	Medium scrumb	,,	Sand	Greyish brown	52	Less stony	7·2	2	1	1	0	1·5	$3·9×10^3$
3	Durga-kund Varanasi	Compact	Fairly sticky	Strongly cemented	Fine massive	Less penetrable	Clay	,,	46	No stones	6·3	1	2·5	0	1	2	$5·8×10^3$
4	Calcutta	Slight crusting	Very sticky	,,	,,	,,	Clayey loam	Dark yellow brown	50	,,	6·2	0	0·5	3	2	0·5	$2·5×10^3$
5	Bombay	Loose friable	Non-sticky	Not cemented at all	Medium scrumb	Not compact	,,	Very dark grey brown	68	Fairly stony	6·75	0	2	1·5	3	4	$1·8×10^3$
6	Dehra Dun	Compact	,,	Strongly cemented	Coarse massive	Fairly compact	Clayey loam	Light brown grey	47	Not stony	7·85	4	2·5	1	2	2	$3·5×10^3$
7	Dehra Dun (Rajpat Road)	,,	,,	,,	Fine massive	Compact	,,	Pale yellow	63	,,	5·25	0	3	2	1	0	$1·2×10^3$
8	Poona	Slight crusting	Very sticky	,,	Coarse blocky	,,	Loam	Dark grey brown	58	,,	7·0	3	2	1	0	4	$2·0×10^3$
9	Parasnath	Loose friable	Non-sticky	Weakly cemented	Coarse crumb	Not compact	Gravel	Reddish brown	42	Fairly stony	6·6	1	3	1	1	3	$3·5×10^3$
10	Rajghat	Compact	Fairly sticky	Indurated	Fine massive	Compact Clay	Clay	Light brown grey	50	No stones	8·0	3	2	0	0	4	$2·8×10^3$
11	Waltair	Loose friable	Non-sticky	Not cemented at all	Medium granular, single grain	Easily penetrable	Sandy loam	Dark red	58	Less stony	6·6	1	1	4	1	1	$5·2×10^3$

Detailed observations of the soil samples collected from eleven parts of country, from places supporting large stands of *Xanthium strumarium* L., showed great variations with regard to surface (loose friable—compact), consistence (non-sticky—very sticky), cementation (weakly cemented—indurated), structure (fine massive platy—coarse crumb—medium granular, single grain), texture (clay—gravel), compactness (easily penetrable—compact), colour (read from Munsell colour chart), pore space (42–68%, after Daubenmire, 1947), total soluble salts (1.2×10^3—5.2×10^3, expressed in terms of conductivity meter reading), pH (5.2—8.0, Pye pH meter), CO_3 (0–4, arbitrary scale for hydrochloric acid test), NO_3 (0.5–3, on an arbitrary scale of 4 degrees, after Misra, 1946), base deficiency (0–4 ; on an arbitrary scale of 4 degrees after Misra, 1946), reductivity (0–3, on an arbitrary scale of 4 degrees, *cf.* Misra, 1946) and organic matter (0–4, on an arbitrary scale of 4 degrees, *cf.* Misra, 1946) as represented in table I.

The porosity of the substratum affect the growth to some extent as the plants growing on substrata with high percentage of pore space showed better performance in terms of fresh weight of the shoot and its length as shown in table II.

TABLE II

Pore space in relation to shoot length and fresh weight of Xanthium strumarium L.

S. No.	Locality	Pore space %	Average measurement of plants/shoots	
			Height in cm.	Fresh wt. in gm.
1.	Botanical Garden	52	138	511
2.	Bhelupur	60	176	712
3.	Ganges bank	58	162	812
4.	University area	50	128	432
5.	Durga Kund	42	98	321
6.	Sagar	62	168	672
7.	Pathankot	32	88	228

Biotic factors

Owing to their unpalatability, the plants of this species are generally not eaten by cattle. In rare cases, the young apical buds of the main shoot are nibbled off by the sheep and goat. The effects due to this biotic operation are practically negligible as the plants generally regenerate from the lower nodes. The plants do not get trampled under foot due to their habit, but may often be cut from the base by man for eradication from cultivated fields. Plants cut down in the early growing season are often seen to regenerate from the lower nodes and give rise to diffuse growths which flower and fruit in the normal way, and those cut down towards the decline of the growing season when they are at a mature stage ripen fruits successfully provided that the anthesis has already occurred before the time of cutting.

Mice were found to eat away the seeds and the young seedlings in the laboratory and they may perhaps be doing the same under the field conditions too. Though a few fungal species have been reported to parasitize the plant (Agarwal 1961 ; Rao 1962 etc.) these seem to do very little harm, if any at all, to it. Inspite of a great variety of insects flocking in great numbers around the plants, the latter

are rarely subject to their predatory effects. In the case of "monsoon" form a kind of megad (caterpillar) enters the stem through the base of the·petiole by making a hole there and eats the inside pith portion of the stem and roots, thus making them a bit hollow and weak. From 0·1 to 2% of the mature plants have been found thus parasitized and except for the fact that they may be somewhat more easily broken off than the uninfected plants, they remain apparently unharmed by borers. The hollow stems and the roots left by the borers are usually occupied by ants, which in their turn seem to do the plants little damage. The seed and the fruit produced by these plants is nevertheless abundant, healthy and viable as that produced by the uninfected ones. In case of the "winter" and the "winter-summer" forms, the leaves are sometimes damaged by predatory insects, but the damages are practically always negligible and the frequency of infection very low (0·01% or less). In the "winter-summer" form and more so in the "summer" form the female of the insect species *Nuphsehra autumnata* bores its way into the fruit and lays eggs on the ovary wall. This insect is rarely (*i.e.* in 1–2% cases) seen to attack the fruits with well developed seeds within and the frequency of attacks is greatest in case of the fruits containing embryoless, shrivelled or even feebly developed seeds within, the latter being developed in response to unfavourable climatic conditions, especially in later growths.

Xanthium strumarium L. is self compatible and does not depend upon any biological agencies for pollination. It sets fruit when inflorescences are placed in cellophane bags and kept without artificial pollination. The seeds from selfing are found to be equally viable as are those from cross pollination.
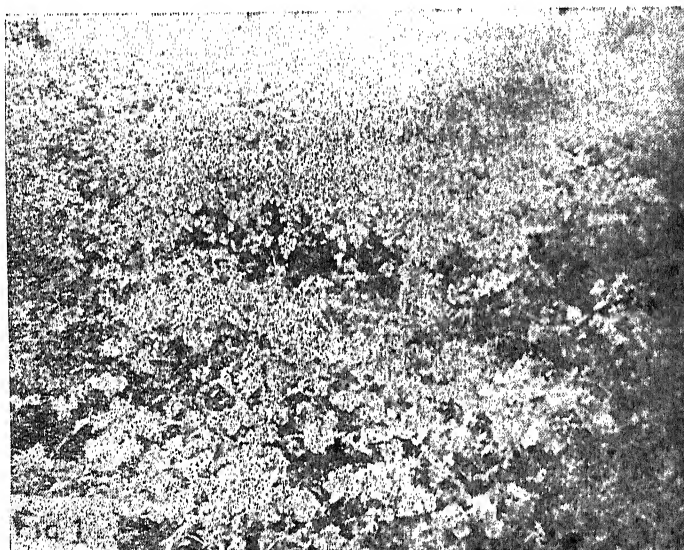
Fig. 1. A thick and pure stand of *Xanthium strumarium* L. along a railway track at Katni.

As far as the inter-specific relationships are concerned, *Xanthium strumarium* L. ('monsoon form') is often found growing in pure stands of its own (Fig. 1), which sometimes or very often extend for miles along the railway tracks, roadsides and the river banks. Whenever in association with other species, it is always the

dominant or on progress towards dominance if the intrusion is comparatively more recent. The various causes for the high invading power of the species may be found in the following :

1. *High Reproductive and Aggressive capacity* :

Salisbury (1942) has defined the average reproductive capacity of a species as the product of the average seed output and the fraction represented by the average percentage germination and the potentiality to colonize and spread or the "aggressive capacity" has often been represented by the product of average reproductive capacity and the average percentage survival of seedlings in its natural habitat.

X. strumarium L. does not multiply by any other means except by seeds. It is, however, a prolific seed producer, the production varying with the vigour of vegetation. Seed production of high viability, is one of the prime qualities that counts for the aggressiveness of the species, in colonizing any unoccupieid or even occupied (by weeding out other species) ecological niche. Sample yelds, taken from two places in Varanasi, two from Sagar and two from Pathankot, showed an average seed production of 500-700 pounds per acre. The area may thus be seeded upto 200-300 per square meter. Seeds in most of the tests (Kaul, 1965b) showed 70-80 percent germination on an average and the sprouting in most of the cases was seen to begin in 4-5 days. The rate of mortality of the seedlings was studied by laying permanent meter quadrats at 4 spots (where a large number of seedlings had appeared at the onset of the rainy season) and counting the number of seeldings at regular intervals of 15 days in Varanasi. The percentage moitality was found to be very meagre, *i.e.*, as low as 0.01-1%, as almost all of the seedlings at the selected 4 spots were seen to survive. The values for the reproductive and aggressive capacities are caluculated and found to lie in the range of 300-400 for each.

2. *Rapid Root and Shoot Development of the Seedling and the Heavy Weight and Large size of the Seeds:*

The other important feature with regard to the aggressive potentiality of *X. strumarium* L. is the rapid growth of the shoot and root of the seedling. The weekly rate of the root and shoot growth under cultural conditions in the growing season (*i.e.* rainy) are presented in Table III.

TABLE III

Weekly rate of shoot and root growth (linear) in cm. in the rainy season

		Weeks starting on 1-7-1957 to 18-8-1957					
		1	2	3	4	5	6
Shoot	:	8·5	15·8	32·0	43·5	52·0	60·5
Root	:	6·8	11·9	20·2	28·0	POT	BOUND

As is apparent from table III the roots showed a very fast growth. They did not grow only linearly but also showed a profuse development of laterals within only a few days after sowing. The roots ramified throughout the soil mass in the pot, till they became pot bound. The quick and profuse development of roots brought the latter into contact with more and more of soil particles with

the result that more of nutrients could be absorbed by the roots and made available to the growing shoots, which in response developed equally fast and in turn made huge quantities of photosynthates available to roots for their further growth and development. As in culture pots, under natural conditions too (in the rainy season), the roots grow rapidly and except where the water table is very near to soil surface or the substratum is water-logged, the roots are very well developed within a few days time and they quickly occupy the surface soil. Clements, Weaver and Hanson (1929) have shown that water is the factor for which plant competition is usually the greatest. The deep tap root system alongwith a highly developed system of laterals would enable *X. strumarium* L. to absorb enough of moisture from shallow as well as deep soil strata and thus to offer a keen competition for other species to grow in its association. In culture pots, when the seeds were sown alongwith the seeds of 25 species of grasses and forbes (especially from its common associates) the plants of this species were seen to weed out the rest because of its more rapid growth. Even when the sowings were made after the associated species had already germinated, the seedlings of *X. strumarium* L. crowded out the other species. This could be said to be partly due to the heavy food reserve in the seeds which would sustain the rapidly growing seedlings during the early growth period, until their roots reach the deeper strata—deeper than those already occupied and depleted of their nutrient content by the roots of the already growing species—of the soil and come to stand on their own. The same was true under natural conditions too, where the roots quickly occupied the surface soil and, therefore, tended to crowd out species that developed more slowly. The roots of this species were always found to reach greater depths than those of the other associated perennial species of weeds or grasses if the subsoil moisture lay at a greater depth.

This combination of unusually prompt and almost complete germination together with the high rate of natural seeding and also the fast root and shoot growth leaves little wanting in the way of the seedling plants. It is little wonder therefore, that it tends both to invade new areas and to maintain its hold on an area once occupied. The heavy natural seeding provided by *X. strumarium*, the rapid germination of seeds when conditions are favourable, the rapid root and top growth made by the seedlings alongwith the high adjustability to the seasonal conditions prevalent in July–November (*i.e.*, growing season) all encourage thick and extensive stands that we see around. Numerous counts, all across north, north-eastern and central parts of India, incidental to travel, showed large stands varying from 80–300 (averaging 100) plants per sq. m. of the species. Such density of population leaves no doubt that the area is intensely occupied and makes clear why other species have difficulty in establishing themselves unless they get artificial aid.

As an intruder the plant species was observed to enter cleared forest areas, herbaceous plant communities and every kind of vegetable and crop field. The most common associates, in communities other than its own, alongwith their abundance under different habitat conditions at Sagar are given in table IV.

The plants of the other three forms would grow alongwith the typical plant species that are characteristic of such habitat conditions. The plants may, however, occur as solitary individuals, if the occurrence is caused by chance transport of the fruit.

TABLE IV
Common associates of *X. strumarium* L. under diff. rent habitat conditions

S. No.	Species	Scale of abundance	S. No.	Species	Scale of abundance
A.	Along sides of water channels		*D.*	Along pond beds	
			15.	*Crypsis aculeata*	4
1.	*Cassia tora*	2	16.	*Polygonum plebejum*	3
2.	*Cassia obtusifolia*	2	17.	*Mollugo lotoides*	2
B.	Level grounds		18.	*Gnaphalium pulvinatum*	1
3.	*Euphorbia geniculata*	1	19.	*Argemone mexicana*	1
4.	*Achyranthes aspera*	1	20.	*Trigonella oculta*	1
5.	*Euphorbia hirta*	1	*E.*	Roadside depressions	
6.	*Tridex procumbens*	1	21.	*Heliotropium supinum*	2
7.	*Justicia simplex*	1	22.	*Polygonum plebejum*	3
			23.	*Chrozophora prostrata*	1
C.	Level grounds and slight depressions		24.	*Sutera glandulosa*	1
8.	*Sporobolus diander*	2	25.	*Potentilla supina*	1
9.	*Paspalidium flavidum*	1	26.	*Nasturtium indicum*	1
10.	*Panicum flavidum*	2	27.	*Argemone mexicana*	2
11.	*Setaria glauca*	2	28.	*Cochlearia flava*	1
12.	*Iseilema anthephoroides*	2	29.	*Cassia tora*	1
13.	*Eragrostis tenella*	2	30.	*Cassia obtusifolia*	1
14.	*Panicum indicum*	2	31.	*Gnaphalium pulvinatum*	2

1—very rare ; 2—rare ; 3—infrequent ; 4—abundant.

As far as intraspecific competition is concerned, the plants growing in less dense stands are often much branched from the base (the branches spreading and ascending). When densely crowded, the plants are tall, 60–150 cm. high, and are little or not branched at all. The competition however tough it may be, may lead to reduced vegetative development, but rarely does it lead to elimination of the individual even in the most densely crowded formations.

Culture Experiments

The following three sets of culture experiments were conducted with regard to the effects of edaphic factor on growth, chiefly to understand the occurrence of the species in diverse habitats as mentioned heretofore :

(A) Effect of different soils (collected from different parts of the country) on germination and growth.

(B) Effect of the various mixtures with soil, such as, sand, lime, coal, dung, kankar, rubbish, cinder and tree litter, on germination and growth.

(C) Effect of salinity and various concentrations of K, Mg, Cu, Fe, Zn, and NO_3 ions on germination and growth.

TABLE V

Germination and growth in relation to different soils (collected from 18 different parts of the country).

Soil No.	Locality from which collected	Colour	Drainage	Organic matter	pH	CO₃	NO₃	Total soluble salts	% Pore space	Base-deficiency	Reductivity	Growth in 5 months (Oct.—Feb.)			
												Shoot length Cm.	Dry wt. spoot gm.	Fruit No./plant	Total germination %
1	Tilak Bhodan Nizamabad	Dark grey	Slow	High	7·1	1	1	2·0×10³	49	0	1	61·5	48·3	65	78
2	Akbarnagar Nizamabad	Dark brown	Medium	High	7·2	0	1	2·4×10³	46·5	1	1	105·0	148·0	279	80
3	Sagar I	Black	Medium	Excessive	7·1	2	2	1·3×10³	58·0	2	2	72·5	96·0	150	68
4	Sagar II	Dark brown	Medium	Little	6·9	0·5	0	0·9×10³	52·0	2	1	87·0	85·5	115	60
5	Sagar III	White	Rapid	Average	7·8	4	3	0·7×10³	62·0	1	0	94·5	95·5	135	68
6	Bapatla	Very dark grey brown	Slow	High	6·8	0·5	1	2·6×10³	52	0	0	85·0	101·5	137	70
7	Shilong (Assam)	Yellowish red	Slow	Little	6·3	0	0	3·3×10³	60	3	1	65·0	75·0	95	58
8	Ramnagar (Jammu)	Reddish brown	Slow	Excessive	7·0	2·5	0	3·6×10³	53	1	0	78·5	102·0	200	64
9	Jammu	Yellowish brown	Slow	Little	5·2	0	0	4·9×10³	42	1	2	109·0	153·0	325	72
10	Jabalpur	Very dark grey brown	Slow	Little	8·5	4	1	2·9×10³	49	1	2	83·0	110·0	239	76
11	Jorhat (Assam)	Light olive grey	Rapid	High	8·0	2	2	3·5×10³	62	2	2	64·5	46·0	74	82
12	Ootacamand	Dark grey brown	Rapid	High	6·7	1	2	2·6×10³	64·5	1	4	55·5	36·0	76	64
13	Hyderabad	Yellowish red	Rapid	Little	7·5	2	1	3·2×10³	36	1	3	46·5	32·0	65	68
14	Jaipur	Dark yellow brown	Slow	Average	7·0	1·5	1	4·0×10³	56·8	0	2	52·5	68·0	85	66
15	Balaghat	Brown	Slow	Average	6·8	1	1	4·2×10³	51·0	0	4	78·8	104·0	129	60
16	Ganges Banks Varanasi	Pale Olive	Slow	Average	7·1	2	4	3·3×10³	47·3	1	3	66·0	58·5	84	68
17	Karwanbeer Varanasi	Yellow brown	Slow	Excessive	6·8	1·5	3	2·7×10³	57	0	1	56·5	46·2	94	74
18	Coimbatore	Yellow red	High	High	7·5	3	1	2·4×10³	36	2	3	42·8	37·0	80	72

A. Effect of different soils on germination and growth :

The importance of transplant experiments in understanding the growth of plants in relation to edaphic conditions is shown by the experiments of the British Ecological Society and Carnegie Institute (Misra and Puri, 1954). In the present experiment, 18 different soils of different origin, nature and composition (characters given in table V) were collected from different parts of the country. Earthen pots were filled with these for testing germination and growth behaviour of *X. strumarium* L. in each. Fifty seeds were sown in each pot and pots were kept in the open. They were watered regularly to the same extent and also kept free from weeds. Out of the numerous seedlings produced only three were allowed to grow in each pot and the rest eradicated. The growth in terms of shoot length, dry weight of the shoot and fruit number per plant was studied at the end of five months. The results are shown in table V.

As is evident from table V, germination was not affected at all by different soils. The growth exhibited, however, was distinctive, but even when at its lowest, *i.e..* in soils 12, 13 and 18, the plants grew to 32–40 cm. height and ripened 70–80 well developed fruits containing viable seeds within. The ripening of the seed of the same size and weight by plants irrespective of the individualistic degree and magnitude of the vegetative growth was quite significant and was seen to be true even in cases where the plants could not grow to more than 3 to 5 cm. high under the prolonged conditions of physiological drought (*viz.*, seedlings grown in lime with restricted nutrient supply through watering ; or seedlings grown in pots, with extensively ramifying roots of parent plant in soil mass, the latter depleting the soil even of the last traces of nutrients). This phenomenon would probably explain the perpetuation of the species in situations ordinarily non-conducive to the proper growth. The species would thus survive by ripening viable seeds irrespective of better or poor vegetative development.

B. Effect of sand, lime, coal, dung, kankar, rubbish, cinder and tree litter on germination and growth :

The germination was indifferent to the nature of the substrata, as the results were same in all the cases, when supplied with sufficient moisture. The growth attained at the end of three and half months period in sand, coal, dung, kankar, rubbish and cinder was in general of a lower order than that attained by plants grown in soil, probably because of the paucity of nutrients under these conditions. The various mixtures of these with soil resulted in enhanced growth than in soil alone. The addition of these materials to soils, probably improved the nutritive status in some cases and the percentage pore space and water relations in others. There was a gradual decrease in growth with an increase in the lime content and plants grown in pots with a good percentage of lime to pure lime remained very much stunted as compared to their counterparts in other sets of experiments. But howsoever stunted the growth, the plant always produced viable seeds, despite limitations of growth and total seed output. The litter of trees enhanced growth to a great extent. Tree litter cannot therefore, be a factor for the absence of the species in forest areas (Kaul 1965*a*).

C. Effect of Na, K, Cu, Fe, Mg, Zn ions and N_2 on germination and growth :

The growth was not very much affected by the addition of the following to the soil in culture pots (the pots were kept in the open, given only one application of the salt in the beginning and watered moderately throughout).

1.	Na	80–160 ppm	soil in the form of	Nacl
2.	K	40–80	„	„	KCl
3.	Cu	20	„	„	$CuSO_4$

4.	Fe	15–20 ppm soil in the from of	$FeSO_4$
5.	Mg	25 „ „	$MgSO_4$
6.	Zn	50 „ „	$ZnSO_4$

The plants could, however, withstand the concentrations of Na upto 720 ppm (of soil), K (120 ppm of soil), Cu (50 ppm of soil), Fe (50 ppm of soil) Mg (120 ppm of soil) and Zn (50 ppm of soil), but the growth exhibited under higher doses of the salts was much limited.

The noteworthy point in these experiments too, was the ripening of the viable seed even on plants under the most stunted and depauperate form of growth. The addition of nitrogen, in the form of $(NH_4)_2SO_4$, upto the extent of 120 ppm of soil was seen to enhance growth to a great extent.

The other three forms also exhibited similar growth behaviour with regard to the edaphic factors.

These forms were grown (from the seed collected in different seasons at Varanasi) in the 18 different soils, collected from different parts of the country (descriptions given in Table V) in transplant experiments and the comparative growth values in terms of dry weight of the shoot, attained in a period of $3\frac{1}{2}$ months (November, 1957—February, 1958) under similar conditions are recorded in Table VI.

TABLE VI

Dry weight of shoot attained by various forms of X . strumarium L. in different soils, collected from different parts of country, under 18 hours daily photoperiod within a period of $3\frac{1}{2}$ months (November, 1957–February, 1958)

| Soil No. | Locality from which collected | Dry wt. of shoot in gm. after $3\frac{1}{2}$ months | | | |
		Monsoon form	Winter form	Winter-Summer form	Summer form
1.	Tilak Bhodan, Nizamabad	48·3	22·0	18·0	21·5
2.	Akbarnagar	148·3	48·5	40·5	42·0
3.	Sagar I	96·0	40·0	38·0	23·0
4.	Sagar II	85·5	38·5	42·0	18·0
5.	Sagar III	95·5	36·0	34·0	35·5
6.	Bapatla	101·5	40·5	42·0	28·0
7.	Shillong, Assam	75·0	39·0	30·0	20·5
8.	Ramnagar, Jammu	102·0	49·0	32·5	42·0
9.	Jammu	153·0	60·0	48·0	45·0
10.	Jorhat, Assam	46·0	20·0	28·0	15·0
11.	Jabalpur	110·0	58·0	56·0	38·5
12.	Ootacamand	36·0	12·0	18·0	16·5
13.	Hyderabad (Dn)	32·5	14·5	20·0	12·0
14.	Balaghat	104·0	43·0	36·0	46·5
15.	Ganges banks, Varanasi	58·5	29·5	21·5	23·5
16.	Karwanbeer, Varanasi	46·0	34·0	20·5	12·0
17.	Coimbatore	37·0	18·5	11·0	13·0
18.	Jaipur	68·0	33·5	18·0	25·0

The most important feature to be noted from Table VI is the characteristic minimum and maximum growth values in terms of the dry weight of the shoot for each form for similar soils, inspite of the fact that the growth was very much circumscribed by the seasonal effects (will be discussed in a later paper in the series). This would probably indicate a similarity between the endogenous rhythm of the various forms towards the adjustability to the edaphic factor, which in turn would very much suggest their origin from the same stock.

Discussion

Much has been done and said about the role of the edaphic factor in governing the growth and distribution of plants. While authors like Miller (1938), De Silva (1934), Kosalva (1934), Hewetson (1951), Bharucha and Dubash (1951) and Pearsall (1952) laid emphasis on single factors such as pH, NO_3, basic ratio, exchangeable calcium etc., Dastur and Saxton (1922) and Misra (1944) attributed much to the varying soil types. Weaver (1938) reported such factors as water content, aeration, soil structure and nutrients to be greatly effective and he further observed that certain species possessed a high degree of plasticity which others lacked in. Similarly Robinson (1947), Daubenmire (1947), Oosting (1948), Gorham (1954), Weaver (1938) and many others have laid great stress on the relation between the soil characters such as moisture, configuration of surface, mechanical and chemical properties of the surface, (i.e., soil texture, soil structure, soil aeration, organic matter component, soil moisture and air, soil solutes, soil pH, salinity, basicity, etc.) and finally on the mechanical and chemical properties of subjacent rocks.

Xanthium strumarium L. possesses a genetical amplitude that allows its growth under diverse substrate conditions.

The species is capable of growth in red soils, lateritic soils, black soils, alluvial soils, desert soils, forest soils, saline soils, besides in marshlands and water-logged habitats.

Though the magnitude and degree of growth may vary with regard to varying soil surface, soil consistence, soil cementation, soil structure, soil texture and compactness, soil colour, pore space, total soluble salts, soil pH, CO_3, NO_3, base deficiency, soil reductivity and soil organic matter, yet the species exhibited a wonderful capacity of perpetuation even under very adverse substrate conditions by ripening a few to many viable seeds irrespective of very much stunted and depauperate vegetative growth.

Both in field and under culture conditions the species was seen to grow on diverse habitat conditions and was besides able to withstand the addition of relatively high dosages of salts of various minerals to the substratum.

Edaphic factor in general could be said to not to be very much effective in restricting or making its growth possible in a particular niche as has been advocated by authors like Misra (1944), Miller (1938), Pearsall (1952) etc. for explaining the distribution pattern of various plant forms. The indifference shown by the species to the varying edaphic factor would on the other hand lend a great support to Shreve's (1951) statement that "the character of soil is of little importance aside from its penetrability and retentiveness with regard to the growth of ephemerals. The depth, structure and mineralogical origin of soils, all so important to perennials mean little to ephemerals. The perennials as linked to

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the standard are affected by the whole complex of the physical and biotic conditions that make up the habitat. The deeply penetrating roots exploit the subsoil moistures."

The soil transplant experiments seem to be very much interesting. The various forms of *Xanthium strumarium* L. showed the minimum and maximum growth values in the same soil type. This would probably indicate a similarity in the endogenous rhythm and the physiology of the various forms with regard to the edaphic factor. The similarity in the endogenous rhthym in the different forms would in turn point to their origin from the same phylogenitic stock.

In the transplant experiments too, the fact that the plants of the various forms did in no case fail to ripen the viable seeds irrespective of very much stunted growth was very much distinct and obvious.

In addition to edaphic and the climatic factors plants are subject to the direct and indirect influences of other living organisms in their environment. Among these are bacteria, fungi, viruses, green plants and animals. Man himself, from the standpoint of a plant is merely one of the factors in its environment. The biotic factors not only disturb the physical sorroundings but also affect plant life directly (Misra 1959). The latter facts have been considered in terms of disjunctive and conjuctive symbiosis by McDougall (1918). Clements (1929) gave the terms "action", "reaction" and "co-action" with regard to the influence of the environment and organisms among and in between themselves, respectively. Stewart and Hull (1949) felt that no ecological study could be complete without recognition of miscellaneous interrelations of other living organisms.

Xanthium strumarium L. is not grazed upon by cattle and nor is it severely parasitized by any bacteria or fungi.

Due to its high reproductive capacity and the rapid growth of seedlings the species offers much competition to other species and thereby flows from point to point, place to place and from state to state through pathways that are bereft of life or even stocked with life at times.

The wonderful power of regeneration when cut even to the base or eradicated and the maturation of viable seeds even on the cut plants or uprooted ones also stands it in a good stead.

Like soil factor, biotic factors also do not at all interfere with its growth and spread and if there is any kind of action, interaction or co-action, at any time, it is to the benefit of the species and to the detriment of its associates.

Summary

Xanthium strumarium L. is indifferent to most changes in the edaphic factors and grows in a variety of soil types and other substrata such as refuse, cinder, compost heaps, etc.

Culture experiments have revealed the species to be capable of growth in a number of soils of different origin, nature and composition (these were collected from different parts of the country) and under the addition of high dosages of lime, dung, Na, K, Fe, Cu, Zn and Mg. salts to the substratum. This would probably explain the growth on saline soils and along the crop fields.

This species is not exposed to any significant biotic disturbance under natural growth. Its aggressive capacity and success in competition with associates in plant communities are due to high reproductive capacity, large size and weight of the seed and fast growth of shoot and root of the seedlings.

The profusely developed root system offers a great competition for water and nutrients to other species which generally succumb to it and thus give way for its mass invasion and establishment into dense stands.

Acknowledgement

I am deeply indebted to Professor R. Misra for his invaluable guidance throughout the course of this investigation.

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TWO NEW SPECIES OF NEMATODES FROM BIRDS*

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Family—Acuariidae Seurat, 1913
Sub-family—Acuariinae Railliet, Henry and Sisoff, 1912

Synhimantus ardeai sp. nov.
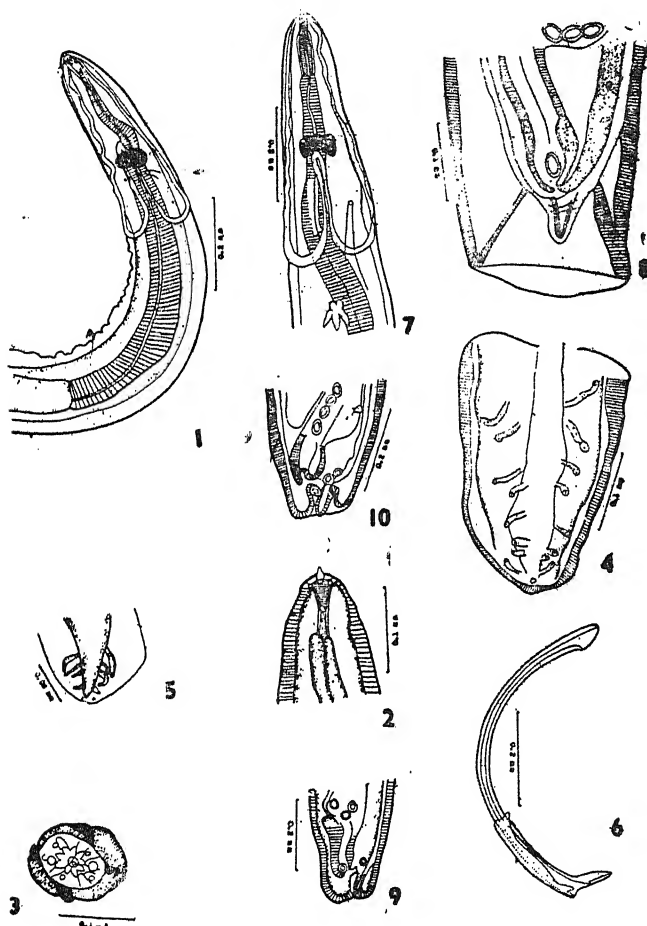
Fig. 1. Male—Anterior region. Lateral view.	Fig. 6. Spicules.
Fig. 2. Male—Anterior region enlarged. Lateral view.	Fig. 7. Female—Anterior end—showing. tricuspid cervical papillae. Lateral view
Fig. 3. End on view.	Fig. 8. Female tail. Ventral view.
Fig. 4. Male tail. Ventral view.	Fig. 9. Female tail. Lateral view.
Fig. 5. Male tip of tail. Ventral view.	Fig. 10. Female tail. Lateral view.

A large number of male and female specimens were recovered from the stomach and rectum of a heron, *Ardea cinerea* Linnaeus at Lucknow.

Description

Body elongated, cylindrical and medium sized ; a slight difference in size of sexes ; male thinner. In end on view, at sides of mouth opening two triangular conical lateral lips. Each lip bears two small symmetrical papillae on outer scurface. A pair of amphids situated laterally. On each corner of head, termination of cordons also visible. Two lateral alae extending throughout body length. Cuticle thin, finely striated, 0·02–0 14 mm. apart in male and 0·03–0 16 mm. apart in female.

Male

Body 8·06 to 9·26 mm. long, 0·22 to 0·33 mm. wide. Head, 0·05–0·08 mm. in diameter with recurrent, anastomosing cuticular cordons extending posteriorly 0·41 to 0·45 mm. from anterior end, then turning forward to end some distance beyond nerve ring 0·23 to 0·27 mm. from anterior extremity. Cervical papillae tricuspid, posterior to cordons 0·54 to 0·64 mm. from anterior extremity. Mouth leads into a short cylindrical vestibule, 0·05 to 0·09 mm. long. Club shaped esophagus divided into two parts, an anterior narrow and muscular portion, 0·83 to 0·89×0·05 to 0·08 mm. in size and a posterior wide and glandular portion 2·2 to 2·98×0·11 to 0·16 mm. in size. Entire esophagus 3·07 to 3·97 mm. long. Nerve ring 0·24 to 0 28 mm. and excretory pore 0·28 to 0·315 mm. from anterior end. Tail bluntly rounded at tip 0·07 to 0·11 mm. long, caudal end curled ventrally and forms two turns of a spiral. Caudal alae broad and well developed extending upto tip of tail, 0·48 to 0·95 mm. long. Eight pairs of pedunculated caudal papillae with four pairs preanal and four pairs postanal. Preanal papillae of either side form two groups of two each. A pair of phasmids observed near tip of tail. Spicules tubular, alate, unequal and dissimilar. Left spicule shorter terminating into two spike like processes 0·17 to 0·31 mm. long, provided with swollen root having a bell shaped expansion from which tip of spicule projects out ending into a sharp pointed end. Right spicule, 0·78 to 0·87 mm. long. Gubernaculum absent.

Female

Body 11·21 to 12·81 mm. long, 0·35 to 0·43 mm. wide. Head 0·05 to 0·08 mm. in diameter with cordons extending to 0·52 to 0·58 mm. from anterior end of body, then turning forward to end below nerve ring 0·25 to 0·30 mm. from anterior extremity. Cervical papillae tricuspid posterior to cordons 0·69 to 0·72 mm. from anterior end. Mouth with a short cylindrical vesibule 0·05 to 0·09 mm. long leading into a long esophagus having an anterior muscular part 0·95 to 1·17×0·08 to 0·11 mm. in size and a long glandular posterior part 1·56 to 3·38×0·12 to 0·20 mm. in size. Entire esophagus measuring 2·64 to 4·48 mm. long. Nerve ring at 0·23 to 0·31 mm. and excretory pore 0·31 to 0·41 mm. from anterior end. Tail bluntly rounded at tip invaginated into a sheath 0·05 to 0·11 mm. long. Vulva at posterior end of body extremely close to anus 0·096 to 0·25 mm. from posterior extremity. Eggs oval, thin shelled, not embryonated, 0·015 to 0·030×0·01 to 0·02 mm. in size.

Discussion

The present form belongs to the genus *Synhimantus* Railliet, Henry, and Sisoff, 1912. Chabaud et Campana-Rouget (1949) divided the genus into two

sub-genera viz. *Synhimantus* and *Desportesius*. The sub-genus *Desportesius* parasitic in ardeiformes is characterised in having a single female genitalia opening posteriorly near the anus, cordons wider in their posterior region with spines always, and cuticle vesiculated. The sub-genus *Synhimantus* parasitic in raptores is characterized in having double female genitalia, vulva in the middle of body, cordons having same width for their entire length without spines and cuticle normal. Yamaguti (1961) has suppressed the genus *Desportesius* Chabaud et Campana-Rouget, 1949 regarding it as a synonym of the genus *Synhimantus*. The author is in agreement with Yamaguti as the presence or absence of spines in cordons in the specimens having a single female genitalia opening posteriorly near the anus are variable characters.

Synhimantus *ardeai* sp. nov. resembles *S. invaginata* (Linst., 1901) ; *S. brevicaudatus* (Duj., 1845) ; *S. sagittatus* (Rud., 1809); *S. raillieti* (Skrj., 1924); *S. orientalis* (Wu, 1933) ; *S. spinulatus* Chabaud et Campana, 1949 ; *S. equispiculatus* var. *spinulatus* Chabaud et Campana, 1949 and *S. canadensis* Mawson, 1956 in having vulva near the anus and cordons wider at the posterior end. However, it differs from all of them in the absence of spines in the posterior region of cordons.

Only two species of the genus *Synhimantus* viz. *S. invaginata* (Linst., 1901) and *S. nana* Maplestone, 1931 from birds have been described so far from India. *S. ardeai* sp. nov. differs from *S. invaginata* in having lateral alae throughout the body length, in the number and disposition of anal papillae and in the size and shape of spicules of which the shorter spicule has two spike like processes at the posterior end *S. ardeai* sp. nov. can also be distinguished from *S. nana* in having vulva close to anus. Accordingly it is regarded as new with the specific name *Synhimantus ardeai* sp. nov.

Host : *Ardea cinerea* Linnaeus
Location : Stomach and rectum
Locality : Lucknow.

Family—Subuluridae Yorke and Maplestone. 1926
Sub family—Subulurinae Travassos, 1914

Subulura albai sp. nov.
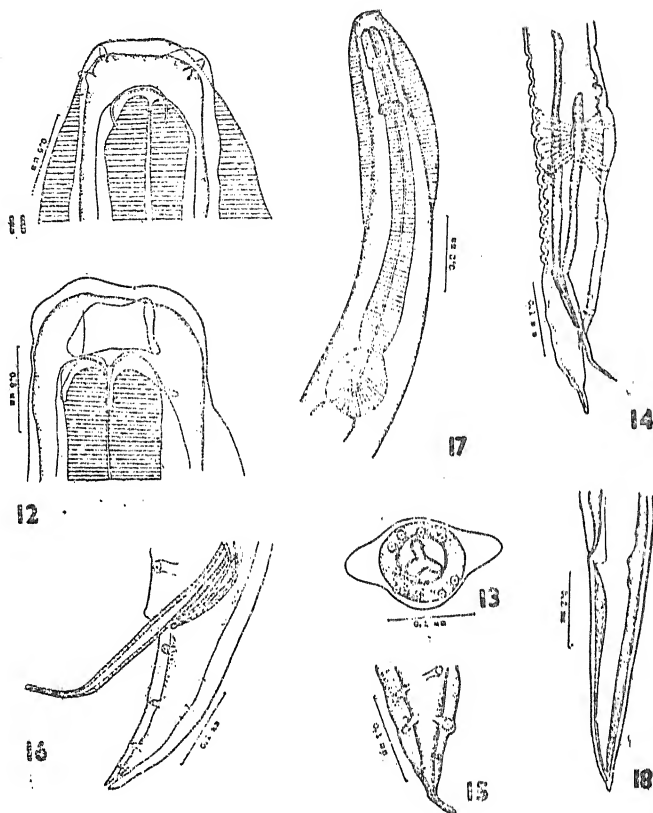
Fig. 11. Male—Anterior end. Latral view.
Fig. 12. Male—Anterior end showing teeth. Ventral view.
Fig. 13. End on view.
Fig. 14. Male tail. Ventro lateral view.
Fig. 15. Male-tip of tail. Lateral view.
Fig. 16. Male tail showing alate spicules. Lateral view.
Fig. 17. Female—Anterior end. Lateral view.
Fig. 18. Female tail. Lateral view.

Four males and three females of which two females are damaged at the posterior end were recovered from the stomach of an owl *Tyto alba* Scopoli at Lucknow.

Description

Body slender, cylindrical, small to medium sized, anterior end curved in form of a hook and posterior end attenuated. Three large strongly chitinized teeth with sharp points situated at base of buccal cavity measuring 0·025 to 0·04 mm. long in male and 0·032 to 0·09 mm. long in female. In end on view mouth surrounded with six small papillae arranged in two lateral series. A pair of amphids situated laterally. Cuticle thin and finely striated. Lateral cervical alae broad, finely striated transversely extending from anterior end for a distance of about 0·61 mm. and with a maximum width of about 0·04 mm. in male, narrow in female and extend upto end of bulb.

Male

Body 11·11 to 11·70×0·22 to 0·31 mm. in size. Head 0·085 to 0·10 mm. in diameter. Two small cervical papillae posterior to nerve ring at 0·42 to 0·48 mm. from anterior end. Mouth opens into a long cylindrical vestibule, 0·085 to 0·13×0·05 to 0·6 mm. Esophagus club shaped dilated posteriorly and followed by a more or less spherical bulb, measuring including bulb, 0·91 to 0·97×0·10 to 0·11 mm. Prebulbar swelling 0·10 to 0·11 mm. thick. Nerve ring at 0·26 to 0·30 mm. and excretory pore 0·31 to 0·40 mm. from anterior extremity. Caudal alae broad and extend upto tip of tail. Tail sharply pointed and curved, 0·20 to 0·27 mm. long including short terminal spike. Anal sucker spindle shaped, 0·09 to 0·14 mm. at 0·34 to 0·39 mm. from cloacal aperture. Eleven pairs caudal papillae with four pairs preanal : two pairs adanal ; and five pairs postanal. Two pairs preanal papillae, long, pedunculated lying on sides of anal sucker and two pairs between adanal papillae and anal sucker. Two pairs adanal papillae close together near cloaca. Two most anterior postanal papillae larger ; two pairs more lateral in position and remaining three pairs small near median line. Spicules similar, equal and alate, broader at anterior end and sharply pointed at posterior end, measuring 0·78 to 0·88 mm. in length. Gubernaculum slender or slightly curved, 0·10 to 0·13 mm. in length.

Female

Body 17·95×0·37 mm. Head 0·09 mm. in diameter. Two small cervical papillae 0·46 to 0·49 mm. from anterior end. Cylindrical vestibule 0·09 to 0·10× 0·06 to 0·07 mm. Prebulbar swelling 0·11 to 0·12 mm. thick. Esophageal bulb 0·19 to 0·21×0·14 to 0·18 mm. Nerve ring at 0·29 to 0·32 mm. and excretory pore 0·34 to 0·49 mm. from anterior end. Tail 0·71 mm. long, narrows near tip to form a fine terminal spike. Vulva preequatorial, slightly anterior to mid region of body, 7·04 to 7·5 mm. from anterior end. In specimens measuring 17·95 mm. in length, vulva lies at 7·04 mm. from anterior end. Eggs oval, 0·02 to 0·04×0·019 to 0·030 mm.

Discussion

The present form is referred to the genus *Subulura* Molin, 1860. Twelve species of this genus have been described so far from birds and mammals from India *viz., S. differens* (Sonsino, 1890) ; *S. olympioi* Barreto, 1919 ; *S. galloperdicis* Baylis et Daubney, 1922 ; *S. multipapillata* (Chandler, 1926) ; *S. turnicis* Maplestone, 1931 ; *S. andersoni* (Cobbold., 1876) ; *H. hindi* Mirza, 1936 ; *S. indica* Khera, 1956

and *S. vulpis* Kheia, 1956. Inglis (1958, 1960) considered that *S. distans* (Rud., 1809) is synonym of *S. turnicis* ; *S. indica* synonym of *Tarsubulura perarmata* (Retzel. 1868) and *S. vulpis*—synonym of *Oxynema alata* (Mazhar, 1933). Yamaguti (1961) considered that *S. hindi* is synonym of *S. andersoni*. The author is in agreement with the above authors. The present form has close resemblance with *S. olympioi* and *S. galloperdicis* in having 11 pairs of caudal papillae. *S. albai* sp. nov. differs from *S. olympioi* in the extension of lateral alae a little anterior to bulb, in larger size of specimens, in having well developed caudal alae, in the arrangement of anal papillae and in having the longer tail. Further *S. albai* sp. nov., can also be distinguished from *S. galloperdicis* in the absence of a spur at the anterior end of gubernaculum, in having broad cervical alae and in the arrangement of preanal papillae. Accordingly it is regarded as new with the specific name *Subulura albai* sp. nov.

Host	:	*Tyto alba* (Scopoli).
Location	:	Stomach.
Locality	:	Lucknow.

Summary

Synhimantus ardeai sp. nov. from the stomach and rectum of a heron, *Ardea cinerea* and *Subulura albai* sp. nov. from the stomach of an owl, *Tyto alba* have been described.

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QUANTITATIVE STUDIES ON THE INTERSTITIAL CELLS OF THE TESTES OF *ANSER MELANOTUS* (AVES, ANSERES)

By

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Introduction

Studies on the interstitial cell cycle of vertebrates have been mostly undertaken to ascertain the relationship between the periods of sexual cycle, activity of seminiferous tubules, quantity of interstitial cells and the development of genital tracts and secondary sexual characters. It has been thought that if the interstitial cells are responsible for the production of the hormone, the amount of these cells in the different phases of the sexual cycle must be an index of the rate of the secretion of the hormone. Whereas many investigators have recorded a marked parallelism between interstitial cell cycle and cyclical changes occurring in the seminiferous tubules, in other cases a marked antagonism between the two has been reported and in a few cases any periodicity in the interstitial cells has been completely denied and in still others the presence itself of interstitial cells has been doubted.

The studies on the interstitial cells of birds have so far been only of a qualitative nature and no attempts have been made by any investigator to estimate the quantitative changes in the interstitial cells of avian testis. Many investigators seem to have confused between the quantity of interstitial cells relative to the germinal tissue and the total number of interstitial cells present. The present paper gives an account of interstitial cell cycle (quantitative) in the testes of *Anser melanotus.*

Material and Methods

After being taken from the freshly caught adult specimens, four to five of which were dissected every month, the long axis and maximum diameter of each testis were measured. The volume of the testis was subsequently calculated by using Rowan's modification of Bissonnette and Chapnick's formula (1930). $V = 4/3\pi (a/2 \times b/2)^2$, where V represents the the volume of the testis, 'a' the long axis and 'b' the maximum diameter.

Small pieces of testes were then fixed in different fixatives *e.g.* Mann's fluid, Bouin Allen (P. F. A. 3), Zenkers fluid etc. As suggested by Baker (1945) better results were obtained when in Zenker's fluid, Potassium dichromate was substituted by Chromic acid. Sections 6μ were cut and the slides stained in Delafield's haematoxylin and eosin or in Mann's methyl blue and eosin. The latter stain gives a very precise differentiation of interstitial cells and fibroblasts and was very useful in leydig cell counts. Better results were obtained if during the upgrading process, 2–3 drops of Ammonia were added to a tube of 90% alcohol.

The technique used by Groome (1940) in *Pteropus* was very useful in the quantitative estimation of interstitial cells present in the testis in the different

phases of the sexual cycle. The radius of a particular field under the microscope was measured by an ocular micrometer and as the thickness of each section was known, the volume of a particular field in view could be calculated. The number of interstitial cells visible in each field was counted. About thirty to forty fields representative for each month were examined and the mean figure of interstitial cells per field caculated.

$$\text{Total number of interstitial cells per testis} = \frac{\text{Volume of the testis} \times \text{Mean number of interstitial cells per field}}{\text{Volume of the field}}$$

Observations

The productive cycle of *Anser melanotus* may be divided into four phases :

(1) Reproductive phase ... January to March
(2) Regressive phase ... April to June, July
(3) Refractory phase ... July to September
(4) Progressive phase ... October to September.

Table I gives a quatitative estimation of interstitial cells in the testis cycle of *Anser melanotus*.

Discussion

Studies on the interstitial cell cycle in the testis of birds or of other animals have generally been of a quantitative nature only and very few attempts have been made to study the quantitative changes in the interstitial cells. In fact in birds no attempt at all has been made in this direction.

Among those who have reported a parellelism between the activity of interstitial cells and the progress of spermatogenetic activity and maturation of testis tubules, mention may be made of Allanson (1931 and 1934), Aron (1924), Craig Bennet (1931), Courrier (1921), Friedman (1898), Herlant (1933), Hohn (1947), Groome (1940), Kehl (1944), Marshall (1949) Miller (1939), Moghe (1949), Rasmussen (1917), Reiss (1923), Shattock and Seligmann (1914), Sluiter and van Oordt (1947) and Vivien (1938).

Bissonnette (1930), Blanchard (1941), Champy (1923), Crouch (1939), Dutta (1945), Humphrey (1921), Lecaillon (1909), Mehrotra (1941), Misra (1941 and 1949), Pezard (1918), Seshachar (1941), van Oordt (1924) and Watson (1919) on the other hand have reported an inverse relationship between interstitial cell cycle and activity of the seminiferous tubules.

Bullough (1939) in *Phoxinus laevis*, Herlant (1933) in the grass snakes, Roberts in the Gentoo penguin (*Pygoscelis papua*) and Stieve (1919) in the european jackdaw (*Colaeus monedula*) did not find any correlation between the development of interstitial tissue and the stages of the sexual cycle. Blount (1929) observed in the horned toad *Phrynosoma solare* that the volume of the individual interstitial cells is greatest during the breeding season but after that the volume decreases whereas the number of interstitial cells is increased.

It is interesting to note that for the same animal two sets of observations are on record. In *Gasterosteus aculeatus* whereas van Oordt (1924) recorded an inverse relationship between the interstitial cells and spermatogenetic tissue, Craig Bennet (1931) found an existing parallelism between the two. In *Rana*

esculenta also whereas Aron (1924) observed that synchronously with the prolifera-
tion and activity of spermatogenetic tissue, there is a proportional increase in the
quantity of interstitial cells, Champy (1933) denied any correlation at all between
the two.

A perusal of Table 1 shows that the interstitial cells in the testes of *Anser
melanotus* have their maximum strength in January and February. It is during
the period that the birds are most active sexually and spermatogenesis proceeds
in full swing in the testes tubules. From March onwards accompanying the
retrogression of the testes, there is a decrease in the number of interstitial cells.
It is interesting to note that even though the interstitial cells reach their minimum
strength in May, the testes do not reach their minimum volume till September.

TABLE I

Quantitative estimation of interstitial cells in the testis cycle of Anser melanotus

Radius of the microscopic field ... ·19 mm.
Thickness of the sections ... 6

Month	Average No. of interstitial cells per field	Average testis volume of the left testis	Total number of interstitial cells
January	44	039836 cu.mm.	292,130666
February	5	397525 cu.mm.	331,270833
March	20	077507 cu.mm.	258,356666
April	28	019951 cu.mm.	093,104666
May	12	010267 cu.mm.	020,534000
June	16	008488 cu.mm.	022,634666
July	68	004773 cu.mm.	054,094000
August	200	004773 cu.mm.	159,100000
September	520	002887 cu.mm.	153,306666
October	132	010267 cu.mm.	225,874000
November	120	013975 cu.mm.	279,500000
December	70	023571 cu.mm.	2749950000

In the months of August to September after the postnuptial testes meta-
morphosis, haemopoietic focii in the testes. Following the proliferation of the
lymphocytes, a new generation of cells begins to appear in the intertubular spaces.
These cells are similar to the "juvenile interstitial cells" described by Marshall
(1949) and "indifferent cells" described by Sluiter and van Oordt (1947). The
present author would prefer to call them as "wandering cells" or the "undiffer-
entiated mesenchymatous cells". Subsequeutly from September to November,
these wandering cells accumulate lipoids and transform into lipoidal interstitial
cells. The intermediate stages in the conversion of wandering cells into the
interstitial cells have been described and discussed by me elsewhere (Mehrotra,
1963). In November and December all the interstitial cells in the testes of *Anser
melanotus* are lipoidal.

The lipoidal interstitial cells with many vacuoles and few mitochondria
in their cytoplasm now change into fuchsinophile cells with abundant mitochon-
dria and no vacuoles. The conversion of the lipoidal cells into fuchsinophile

cells proceeds in the month of January and February which are the peak periods of sexual activity. By February, when spermatogenetic activity of the tubules is at its peak, almost all the interstitial cells are fuchsinophile.

Thus the present study on the interstitial cells of *Anser melanotus* clearly establishes that there exists a parallelism between the quantity and quality of interstitial cells and the progress of tubule activity. In the birds Bissonnette (1930), Blanchard (1941), Crouch (1939), Mehrotra (1941), Misra (1941 and 1949), and Watson (1919) have reported an inverse relationship between the development of interstitial cells and progress of spermatogenitic cycle. My observations on the testes cycle of *Anser melanotus* agree with those of Benoit (1923), Hohn (1947), Marshall (1949 and 1951) and Sluiter and van Oordt (1947 and 1949) that the periodic changes in the number of interstitial cells look fewer in the mature testes but taken absolutely, there takes place a definite increase in their number.

Summary

A quantitative estimation of interstitial cells in the different phases of the testis cycle of *Anser melanotus* establishes that with the overall enlargement in the testis volume and ripening of the tubules, there is an accompanied increase in the number of interstitial cells, though relative to the spermatogenetic tissue they look fewer.

Haemopoietic focii appear in the testicular interstitium in the Refractory phase of the testis cycle. Following the proliferation of the lymphocytes in the intertubular spaces, a new generation of wandering cells or undifferentiated mesenchymatous cells begins to appear. The wandering cells later accumulate lipoids and transform into lipoidal interstitial cells. During the reproductive period the lipoidal cells transform into fuchsinophile cells with abundant mitochondria and no vacuoles.

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APOMIXIS IN PASPALUM I: PASPALUM DILATATUM POIR*

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Introduction

Apomixis is common in the flowering plants especially in Compositae Rosaceae, and Gramineae. For the Gramineae, Nygren (1954) listed apomixis in 35 species of 11 genera, and Brown and Emery (1958) found apomixis in 43 species out of 72 species studied. Usually polyploid and perennial species of grasses are apomictic although many polyploid and perennial species are sexual. Kennedy (1900) for the first time described the structure of the embryo of *Paspalum pubiflorum glabrum.* Since then number of species of *Paspalum* have been studied : occassional apospory in *P. scrobiculatum* (Brown 1958) ; apomixis in *P. notatum* (Burton 1948) ; *P. secans* (Snyder 1957) ; and *P. hartwegianum* and *P. melacophyllum* (Brown and Emery 1958). Shadowsky (1926) and Bennett (1944) have published accounts of the embryology of the pasture plant *P. dilatatum.* In tracing the developmental history of the embryo Bennett paid particular attention to the rate and sequence of the growth of its various parts. Herbariums of *Paspalum dilatalum* collected from different parts of the world in The Royal Botanic Gardens. Kew, are found variable and polymorphic. The present paper deals with the cytology and embryology of different accession of *Paspalum dilatalum* to elucidate the cause of its polymorphism.

Materials and Methods

Seeds were received from Nigeria by Mr. W. H. Foster, from The Botanic Gardens, Toulouse, France, and from The National Botanic Gardens, Lucknow, India. Seeds were grown in glass house specially adapted to provide humid tropical conditions at Queen Mary College, London, and in *The Chelsea Physic Gardens, London.

Young root tips of seedlings and young anthers were used for chromosome studies. Root tips were pretreated with 0·002 M 8-hydroxyquinoline for three to four hours before fixation. The fixing fluid used was acetic alcohal. The acetocarmine or Feulgen sqash technique was used for staining chromosomes. Photomicrographs were taken while the preparations were still temporary. Slides were made permanent in Euparal after the usual dehydration.

Material for the study of megasporogenesis and megagametogenesis was fixed in either Belling's Navaschin or acetic alcohol. Before fixing, the florets had been removed from the inflorescences and the distal half of each floret had been cut off in order to facilitate penetration of the fixing fluid. The glumes and lemma were removed prior to embedding, because the glumes were sufficiently hard to cause difficulty in sectioning. The sections were cut 10 to 5μ thick and stained with Heidenhain's ironhaematoxyline, iron alum being used as a mordant and picric acid as a destaining agent.

Some of the preparations were photographed under the microscope and others were drawn using the camara – lucide.

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*It is a part of the thesis submitted for Ph.D. degree of University of London.

Observations

Cytological studies : The material from Nigeria and India showed cytological similarities, 50 chromosomes being observed in root tip mitosis. In the French material chromosome numbers ranging from 40 to 63 were found in different root tips (Fig. 1). In meiosis, in the material from India and Nigeria, 10 univalents appeared at diakinesis and metaphase I (Figs. 2 A–C) and at anaphase I, where univalents remained as laggards, sometimes separating into chromatids which passed to the poles of the same division (Figs. 2 D–F). In dyads, some chromosomes were left outside the interphase nuclei near the point of septum formation (Figs. 2 G–I). In tetrads and pollen grains 1 to 4 chromosomes or micronuclei were seen outside the nuclei (Figs. 2 J–L). It is clear, therefore, that there is a definite loss of chromosomes in microsporogenesis. The further embryological study contributes evidence of apomixis in this species.

Development of Ovule : The ovule is anatropus (Fig. 3). The archesporium consists of one cell. It is distinguished by its large size, dense cytoplasm and prominent nucleus. The cell divides periclinally into two cells—an outer parietal cell and inner primary sporogenous cell. By this time the inner integument primordium is formed and elongated to envelop the nucellus. The outer integument becomes well defined. The cells in the micropylar region of the nucellar epidermis subsequently undergo three to four periclinal divisions to form rows of six cells (Figs. 4 A–C).

The striking fact in this species is the frequent collapse and degeneration of the primary sporogenous cell prior to the onset of meiosis (Figs. 4 B, C). Adjacent to this degenerating cell one or more enlarged nucellar cells are seen (Figs. 4 B, C).

Origin of Embryo-sac : The embryo-sac develops from one of these prominent nucellar cells. The nucleus divides to form two nuclei, one migrates towards the micropylar and the other towards the chalazal end (Fig. 4 C). Each one further divides to form four nuclei at each end ; afterwards one nucleus from either end moves towards the centre (Fig. 4 E). The egg nucleus enlarges to a much greater extent than the two synergid nuclei. The 8-nucleate embryo-sac differentiates into a mature gametophyte which is morphologically of the *Polygonum* type, with two synergid, an egg, two polar nuclei and three antipodales (Fig. 4 E). The antipodal cells usually undergo further divisions to form a 12 to 16—celled antipodal tissue (Fig. 4 F), comparable with that found in many grass species, *e.g. Paspalum secans* (Snyder 1957). Each cell may contain one to four nuclei as in *Paspalum scrobiculatum* (Narayanswami 1954). The plant thus is an example of apospory (Gustafsson 1946) or somatic apospory (Maheshwari 1950).

Pseudogamy : The pollen tube enters the embryo-sac by penetrating the micropyle. The persistent tube is frequently seen lying close to the endosperm nucleus (Fig. 4 H). Two male nuclei and a smaller vegetative nucleus are also observed in the pollen tube. The synergids and pollen tube nuclei have been observed still lying in the embryo-sac when a 64-celled embryo has developed. Embryo development begins before or about the time of anthesis.

Embryogeny : Generally the young embryo develops adventitiously, *i.e.* it arises from nucellar cells (Fig. 4 H). An embryo is also sometimes developed from the egg (Fig. 4 G). Sometimes two embryo develop, one from the egg cell and the other from a nucellar cell (Fig. 5), but polyembryony is never seen in the mature seed ; one of these embryos therefore fails to develop far.

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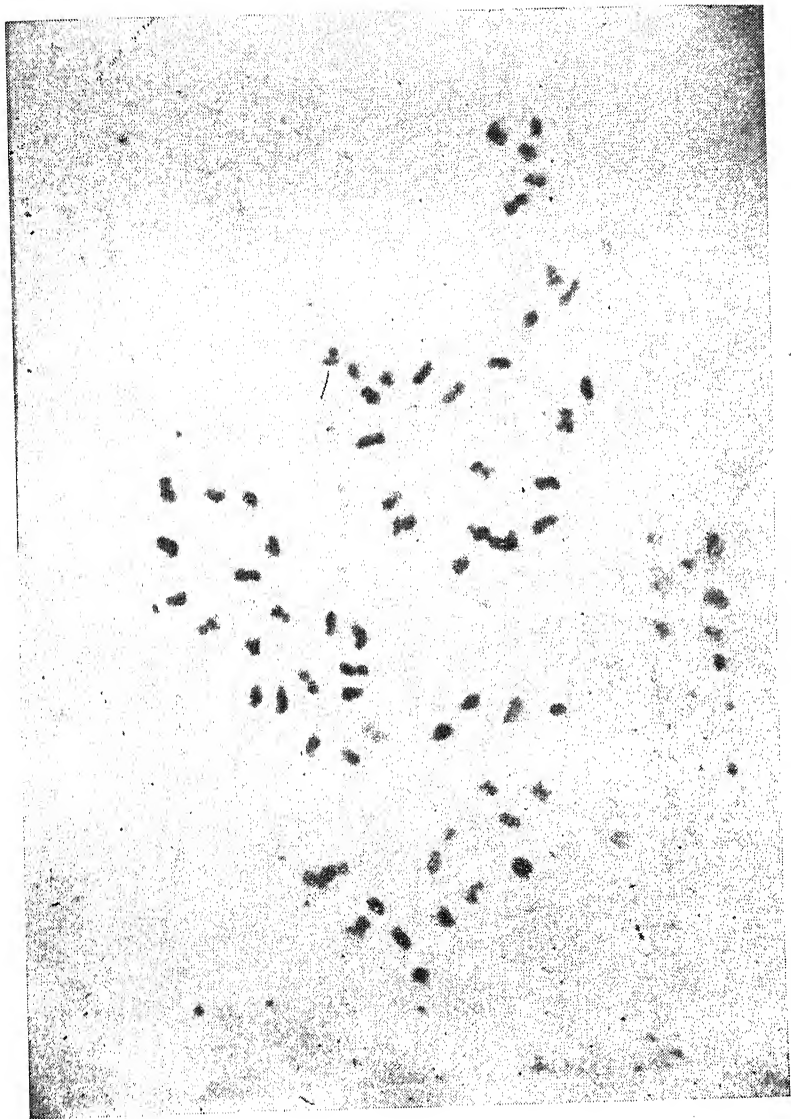
Fig. 1. *Paspalum dilatatum* : Somatic metaphase showing 63 chromosomes, X4332.
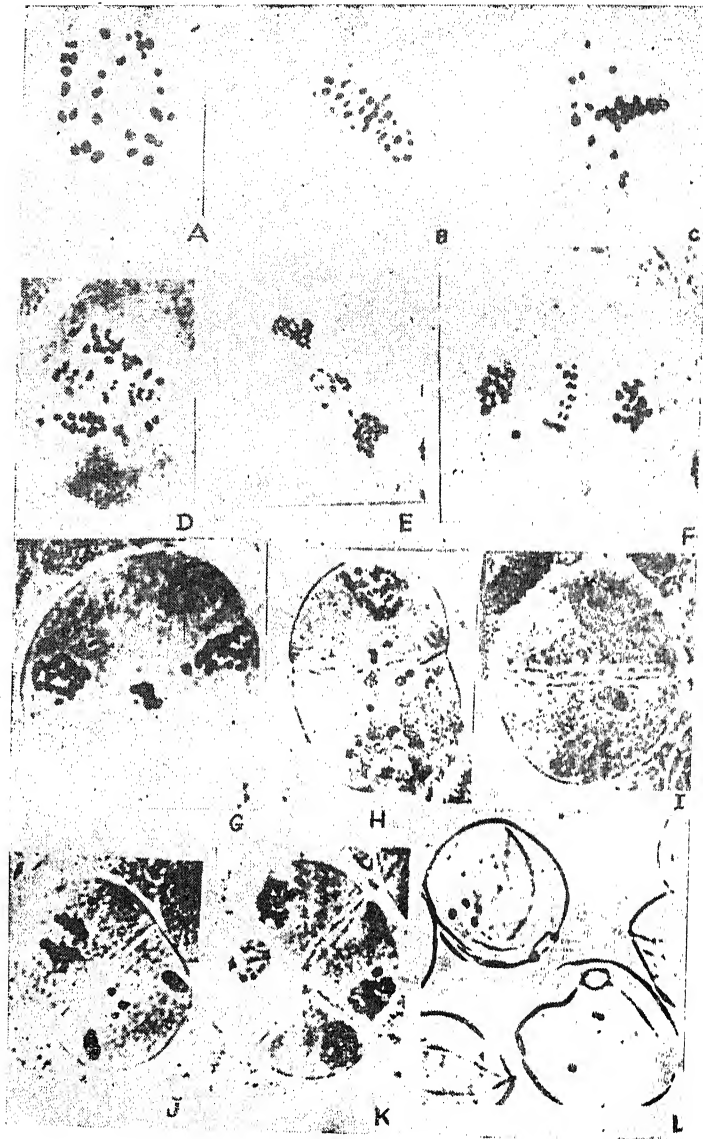
Fig. 2. *Paspalum dilatatum* : Different stages of microsporogenesis.

(A) Diakinesis stage showing 20 bivalents and 10 univalents,
(B) Early metaphase I, bivalents and univalents are seen,
(C) Late metaphase I, univalents are seen scattered in the spindle, some having reached the poles, bivalents are on the equator.
(D) Early anaphase I, univalents are seen in the centre ; already their chromatids are beginning to separate,
(E) Late anaphase I, univalents are in the centre,
(F) Late anaphase I 10 univalents whose chromatids are already separated, are seen at the equator while the bivalents have nearly reached the poles.
(G) Univalents aggregating to form or centrally place micronucleus,
(H) Dyad stage, nuclei are in interphase while some univalents which have been left one are seen near the septum,
(I) Micronucleus is included in one dyad.
(J) Chromosomes being left one of daughter nuclei at anaphase II
(K) Tetrad, one or two micronuclei are seen outside the tetrad nuclei
(L) Micronuclei are seen outside the tetrad nuclei

Fig. 3. *Paspalum dilatatum* : L. S. of an ovule showing anatropous position X100.

Fig. 5. *Paspalum dilatatum* : L. S. of embryo-sac. Two young embryos, are developing from the egg and the other developing from a nucellar cell. X100.

Fig. 6. *Paspalum dilatatum* : L. S. of mature embryo. X100.
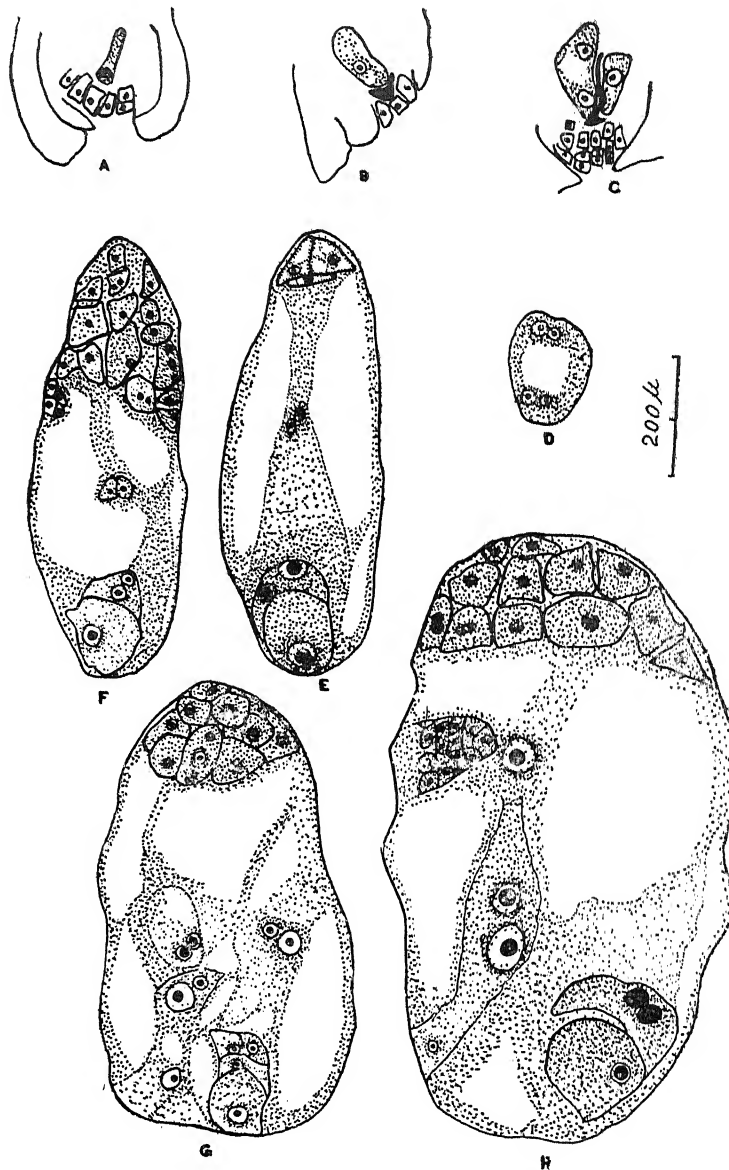
Fig. 4. *Paspalum dilatatum* : Different stages of megasporogenesis and Embryogeny.

(A) Primary megasporocyte,
(B) Degenerating megasporocyte and a enlarged nucellar cell,
(C) Two enlarged nucellar cell, with a degenerating cell between them,
(D) and (E) Stages of development of the female gametophyte,
(F) Mature embryo-sac with considerable antipodal tissue,
(G) Embryo developing from egg cell. Pollen tube with nuclei are also seen.
(H) Adventitive embryo developed from a nucellar cell, in the presence of the unfertilized ovum and the male cells.

The first division of cell which is going to form an embryo is transverse giving rise to a bigger basal cell, known as the suspensor cell, and an upper small cell which divides further transversley and longitudinally to the 64-celled embryo.

Structure of Mature Embryo : Further development of the embryo follows the course described by Bennett (1944) for this species, and by Kennedy (1900) in *Paspalnm pubiflorum*. No epiblast is seen in the embryo. It has a long radicle. The scutellum bundle is inserted some distance from the plumule and there is only one seedling leaf in the mature embryo (Fig. 6).

Endosperm : The endosperm nucleus starts dividing after the embryo has attained 64 cells. No evidence suggesting the union of a male nucleus with a polar or secondary nucleus was found. Several unfertilized shrunken ovules were seen with numerous endosperm nuclei. These are apparently formed by the division of the polar nuclei but presumably fail to develop into endosperm as there was no stimulus either from the pollen tube or male nuclei.

There are 70 to 80 percent seeds found non-viable and shrunken, presumably no embryo develops in them.

Discussion

In *Paspalum dilatatum* the occurence of meiosis in the magaspore mother cell is of little importance since this always degenerates and the functional embryo-sac is a purely somatic cell originating from the nucellus. Meiosis in the pollen mother cell, however, may be of fundamental importance here ; this meiosis is irregular (Figs. 2 A–L) and the irregularities also exists in the pollen grains so far as their genomic build up is concerned. Since the stimulus for embryo development here is the entry of the pollen tube into the embryo-sac complete with tube nucleus and male cells, which are seen at the end of the open tube (Figs. 4 G, H,), it may well be that the viability or non-viabillty of these male cells determines the viability or non-viability of the resulting seed ; since it is clearly possible that fusion of a male cell with the polar nuclei may be needed for endosperm development. This may be the reason for the necessity of pollination, despite the parthenogenetic nature of the plant ; and the fact that only 20–30 percent viable seeds are formed.

In most pseudogamous species such as *Allium odorus* (Modilewski 1930), *Potentilla* species (Rutishauser 1943), *Poa* species (Akerberg 1943, Hakanson 1943), *Parthenium incanum* (Esau 1946), *Paspalum secans* (Snyder 1957) and *Panicum maximum* (Warmke 1954), the embryo begins to develop autonomously and even precociously, but the endosperm will not develop unless it is fertilised. Pollination and partial fertilization are therefore essential for continued growth of the embryo and endosperm.

Reports from other authors on *Paspalum dilatatum* Poir are as follows : in mitosis, Brown (1948) found $2n = 40$, Krishnaswamy (1940) $2n = 50$, Smith (1948) $2n = 40$, Hayman (1956) $2n = 50$. In meiosis, Hayman found 10 univalents and Smith 20 univalents. Both these authors found regular or nearly regular behaviour of the univalents. Like many other pseudogamous apomictic species, *Paspalum dilatatum* has irregular meiosis (Gustafsson 1947 ; Darlington 1937 ; Harlan 1949 ; and Celarier and Harlan 1957). Previous records in the genus (Brown 1958 ; Brown and Emery 1958) show that apomixis is common, being found in nine species, which are polyploid and perennial, although five polyploid and perennial species are sexual. *Paspalum scrobiculatum* is recorded as both apomictic (Brown 1958) and sexual (Narayanswamy 1954).

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Being an apomictic species *Paspalum dilatatum* should have been non-viable. But polymorphism in this species may be due to the fact that if contains chromosome races with 2n = 40, 50 and 63. Occassional hybridization and its segregants may also be another factor for polymorphism. An embryo with 2n = 63 could have arisen by fusion of an egg cell with 2n=40 and an aneuploid male nucleus with n = 23.

Summary

1. Chromosome races have been found in *Paspalum dilatatum* Poir with 2n = 40, 50 and 63.

2. Meiosis is irregular. Univalents of Metaphase I form micronuclei in tetrads and pollen grains. So there is a definite loss of chromosomes in mirosporogenesis.

3. Megasporogenesis and the breeding behaviour indicate aposporous and pseudogamous in *Paspalum dilatatum*.

Frequent collapse and degeneration of the primary sporogenous cell prior to the onset of meiosis is observed. It is from one of the enlarged nucellar cells lying adjacent to the degenerating cell that embryo-sac develops. Embryo arises from nucellar cells. As early stage polyembryony have been observed. Endosperm does not develop without fertilisation. Pollination and partial fertilisation are essential for the growth of the embryo and endosperm.

4. Mature embryo has a long radicle and no epiblast. Only one seedling leaf is found.

5. Polymorphism in *Paspalum dilatatum* is attributed to chromosome race and its hybrid nature.

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THE MUSCULATURE OF THE HEAD OF MYRMELEON LARVA (NEUROPTERA, MYRMELEONIDAE)

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Introduction

The change over of piercing and sucking types of mouth parts of the larvae of several Neuroptera to chewing type of mouth parts of their adults presents an interesting problem for morphological investigation, particularly the comparative study of the cephalic musculature of larvae with that of the adults. There are many lacunae in the detailed knowledge of cephalic musculature itself besides the general morphology of the Neuroptera as a whole (Crampton, 1917, 1921, 1923; Ferris and Pennebaker, 1939). As for example the works of Lozenski (1908) and of Withycombe (1925) on the larvae of *Myrmeleon* and *Planipennia* respectively lack details of the cephalic musculature. Crampton (1921) and Das (1937) also restricted their studies only to the musculature of the maxillae and the labium. However, Rober (1941), Kramer (1955) and Heinz (1961) have attempted to study the cephalic musculature of the larva of *Sialis*, *Corydalus* and *Osmylus* respectively.

Further a rich assemblage of Neuropterous insects having different habits and habitats *e.g.* predatory and parasitic, aquatic, semi-aquatic and terrestrial is expected to modify cephalic musculature accordingly. Thus amongst these insects an opportunity is available to make a comparative study of morphological patterns of cephalic musculature and to correlate them with their diverse feeding habits.

This paper deals with for the first time the cephalic musculature of the larva of an Indian *Myrmeleon*. The homologies of its cephalic appendages with the plan of a generalised insect have also been discussed. The cephalic musculature of the adult *Myrmeleon* will be published as part two of the present study.

Material and Method

Full grown *Myrmeleon* larvae were collected from the field situated near the urban locality of Adarsh Nagar, Ajmer (India). A large number of specimens

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were found around a local plant, *Polyalthia longifolia*. The larvae were killed and preserved in a solution of chloral hydrate and phenol. Dissections were done under stereioscopic binocular microscope in 70% alcohol.

Head

The head of *Myrmeleon* larva is triangular and dorsoventrally compressed. The mouth parts are broadly articulated to the anterior margin of the epicranium. Due to lack of well marked sutures the sclerites of the head are not distinct. The head is bordered posteriorly by the post-occipital ridge (Fig. 1, POCR). The occipital suture (Fig. 1, OCS) is very faint and as such the extents of the region of the occiput are not clearly marked. The coronal suture (Fig. 1, CS) is indistinct but the frontal arms (Fig. 1, FS) of the ecdysial cleavage line are prominently disposed anterolaterly ; they extend on each side up to the region between the bases of the antennae and the ocelli. Just below the frontal arms there lies a small median area, the frons (Fig. 1, FR). The clypeus (Fig. 1, CL) is present between the labrum and the frons. The clypeal sutures are not visible. The labrum (Fig. 1, L) is fairly broad. Its anterior margin is characterised by the presence of a median notch. The outer margin of the labrum possesses thick spicules ; the two middle spicules incline deeply towards each other.

The sides of the head constitutes the genae (Fig. 1, G). An anterior projection of the genal area, on either side of the head, bears the antenna. Each antenna is divisible into a scape, pedical and a long flagellum consisting of fourteen segments (Fig. 1, FL). A group of seven ocelli is present at the sides of the head adjacent to the base of the antenna.

On the ventral side of the head the labium is represented as a large plate (Fig. 2, LB). From this plate arise two labial palpi (Fig. 2, LP). The basal joint of each labial palpus is very much enlarged. The mandibles (Fig. 1 and 2, MD) are attached at the sides of the anterior margin of the head. Each mandible is beset with a number of small and large pointed spicules. On the ventral side of the mandible lies a groove wherein the long sickle shaped blade of the maxilla (Fig. 2, MX) fits. Each maxilla besides having the long sickle shaped blade also possesses two triangular plates, the stipes and cardo (Fig. 7, ST, C) at its base.

Tentorium

The tentorial bridge, (Fig. 3, TB) which is formed by the union of anterior and posterior tentorial arms, appears like an arch. The anterior arms (Fig. 3, AT) are large and strong. The dorsal tentorial arms (Fig. 3, DT) arise as thin sclerotised offshoots of the anterior tentorial arms. The posterior arms (Fig. 3, PT) are short and blunt. According to Withycombe (1925) the posterior arms of the tentorium show a tendency to atrophy in the members of the family— *Myrmeleonidae*.

Muscles of the labrum

Lateral labral muscles are paired, each of which arises from the dorsolateral aspect of the frons and is inserted on a small apodeme situated on the posterolateral corners of the labrum (Fig. 4 : 1).

Dorsal labral muscles are paired (Fig. 4 : 2). They originate together from the midposterior region of the frons and are inserted medially on the base of the labrum.

Compressor muscles of the labrum are small and paired (Fig. 4 : 3). They are situated inside the labrum itself connecting its ventral and dorsal walls.

The contraction of the lateral and dorsal labral muscles brings retraction of the labrum, whereas the compressor muscles are responsible for the compression of the dorsal and ventral surfaces of the organ.

Muscles of the mandible

Lateral mandibular extensor is fan shaped (Figs. 5 and 6 : 4) and arises from the gena to be inserted on an elongated tendon at the outer lateral end of the mandible (Fig. 6, TN).

Mesal mandibular flexor muscle is thick and forms the greater bulk of the head capsule. It originates from a large area including the vertex, occiput and a part of gena (Fig. 5 : A, B, C). The fibres of the muscles at their origin are seen disposed off in three large groups ; they then converge to form a common tendinous base. The latter is attached to a highly sclerotised condyle situated on the lateromesal aspect of the base of the mandible.

The heavy musculatures of the mandibles in this insect bears a special significance since they are used for grasping and piercing the body of the prey. The contraction of the huge flexor muscle brings such a forceful flexion of the mandible that they get inserted deep into the body of the prey. The extensor muscle on contraction brings relaxation of the grip.

Muscles of the maxilla

Cardo-cranial muscle is some what fan shaped (Fig. 8 : 6). It originates from the lower genal area of the cranium and is inserted on a raised tendinous projection of the cardo.

Cardo-tentorial muscle (Fig. 8 : 7) arises from the tentorial bridge and is inserted on the ventral face of the cardo.

Stipital-tentorial muscle originates from the tentorial bridge and is inserted on the base of the stipes (Fig. 8 : 8).

Stipital-cranial muscle is long and cylindrical (Fig. 8 : 9) and originates from the posterior genal area of the cranium to be inserted on a sclerotised part of the distal lateral edge of the stipes.

Dorsal and ventral muscles of the maxillary blade are two in number (Fig. 8 ; 10 and 11). They arise from the mesal aspect of the base of the stipes and are inserted on the dorsal and ventral aspects of the wall of sickle shaped prolongation of the maxilla.

Muscles of the labium and hypopharynx

The hypopharynx does not form a free lobe. It is coalesced with the posterodorsal surface of the labium. The muscles associated with these organs are as follows :

Proximal median ventral muscles are small and paired (Fig. 9 ; 12). They originate from the middle region of the labial plate and are inserted together on the ventral aspect of the latter.

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Lateral retractor muscles are paired each of which originates from the tentorial bridge to be inserted on the outer lateral aspect of the base of each labial palpus (Fig. 9 ; 16).

Dorsal retractor muscles are paired (Fig. 9 ; 13). They originate from the tentorial bridge and are inserted on the base of the labium. They do not originate from the gula as was described by Kramer (1955) in *Corydalus* larva and Maki (1936) in *Chauliodes formosanus*.

Ventral retractor muscles are paired (Fig. 9 ; 14), run ventrally to the dorsal retractor muscles, and originate from the ventral aspect of the labial wall to be inserted on the base of the labium.

Muscles of the salivos are paired (Fig. 9 ; 15). They originate from the midlateral aspect of the labial wall to be inserted on each side of the opening of the salivary duct.

Muscles of the labial palpi are the extensor muscles ; in each palpus two extensors are present. The first extensor muscle (Fig. 9 ; 17) originates from the base of the first segment of the labial palpus and is inserted on outer lateral region of the segmental joint present at the opposite side of that very segment. The second extensor muscle (Fig. 9 ; 18) which originates from the base of the second segment of the labial palpus also shows an identical disposition.

Hypopharyngeal muscles are paired, each of which originates from the tentorial bridge, runs ventral to the pharynx, and is inserted to the hypopharynx (Fig. 10 ; 19). The mouth angle retractor muscle described by Kramer (1955) in *Corydalus* larva is absent in the larva of *Myrmeleon*.

Muscles of the pharynx

All the pharyngeal muscles originate from the head capsule. The contraction of these muscles dilates the pharyngal cavity and as such they are often designated as dilator muscles. A group of six muscles is inserted on the dorsal wall of the pharynx while another group consisting of two muscles is inserted on the ventral wall of the pharynx.

The first muscle (Fig. 10 : 21) originates from the anterior frontal region of the head and is inserted on the anterior aspect of the pharynx. It lies behind the cibarial muscle (Fig. 10 ; 20) which is made up of four to six bundles of fine fibres. The second muscle (Fig. 10 ; 22) is inserted on the pharynx anterior to the brain. The third, fourth and fifth muscles (Figs. 10 ; 23, 24, 25) are inserted on the pharyngeal region which corresponds to the area occupied by the brain. The sixth muscle (Fig. 10 ; 26) is inserted on the pharynx posterior to the brain.

EXPLANATION OF FIGURES

Fig. 1. Dorsal view of the head.

Fig. 2. Ventral view of the head.

Fig. 3. Posterodorsal view of the tentorium.

Fig. 4. Partially dissected frontoclypeal apotome to show the labral muscles.

Fig. 5. Dissection of the head to show the mandibular muscles.

Fig. 6. Dersal view of the mandible with mandibular muscles.

Fig. 7. Dorsal view of the right maxilla.

Fig. 8. Dorsal view of the dissected maxilla with its muscles.

Fig. 9. Dorsal view of the dissected labium to show the labial muscles.

Fig. 10. Lateral view of the foregut wit cibarial, pharyngeal and hypoparyngeal muscles

ABBREVIATIONS

AN—Antenna. AT—Anterior tentorial arm. BR—Brain. C—Cardo. CL—Clypeus. CS—Coronal Suture. DT—Dorsal tentorial arm. FL—Flagellum. FR—Frons. FS—Frontal suture. G—Gena. L—Labrum. LB—Labium. LP—Labial Palp MD—Mandible. MTH—Mouth. MX—Maxilla. OC—Ocelli. OCS—Occipital suture. P—Pedicel. POCR—Post-occipital. ridge. PT—Posterior tentorial arm. PTP—Posterior tentorial pit. S—Scape SG—Sub-Oesophageal ganglion. ST—Stipes. TB—Tentorial bridge. TN—Tendon.

1—Lateral labral muscle 2—Dorsal labral muscle. 3—Compressor muscle. 4—Leteral mandibular extensor. 5—Mesal mandibular flexor. 6—Cardo-Cranial muscle. 7—Lateral cardotentorial muscle. 8—Stipital tentorial muscle. 9—Stipital cranial muscle. 10—Dorsal muscle of maxillary blade. 11—Ventral muscle of maxillary blade. 12—Proximal median muscle. 13—Dorsal retractor muscle 14—Ventral retractor muscle. 15—Muscles of Salivos. 16-Lateral retractor muscle 17—First extensor of labial palpus. 18—Second extensor of labial palpus. 19—Hypopharyngeal muscle 20—Cibarial muscles. 21-26—Dorsal pharyngeal muscles. 27-28—Ventral pharyngeal muscles.

Fig. 1

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AN
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Fig. 2

ATP
AT
DT
PT
TB   Fig. 3

Fig. 4
1
2
20
3

A
4
C

B
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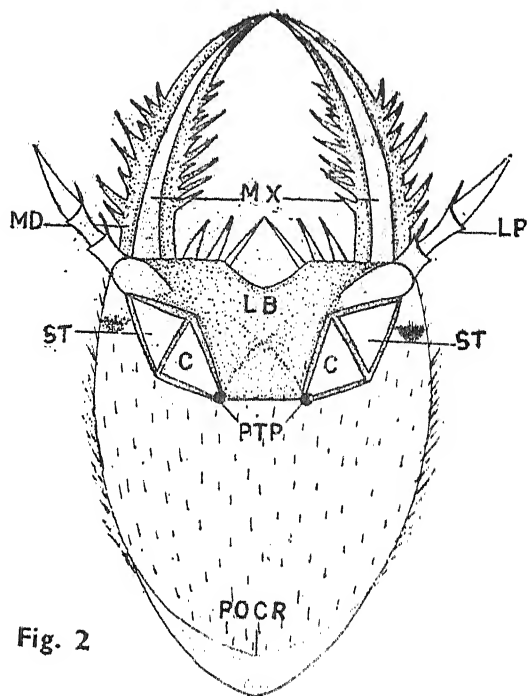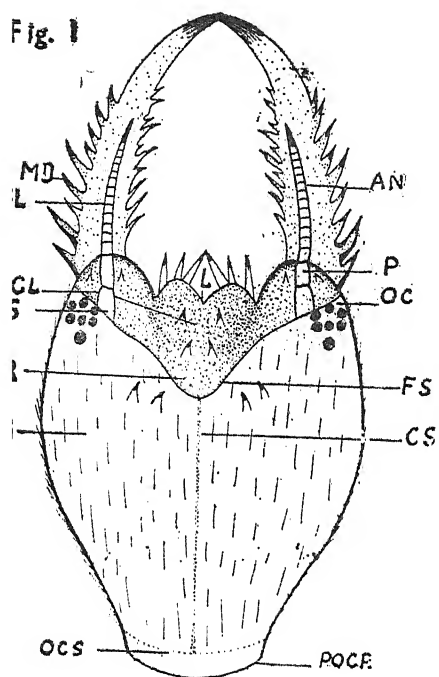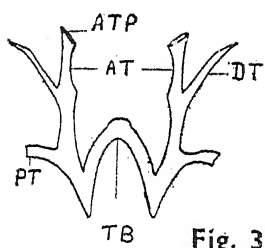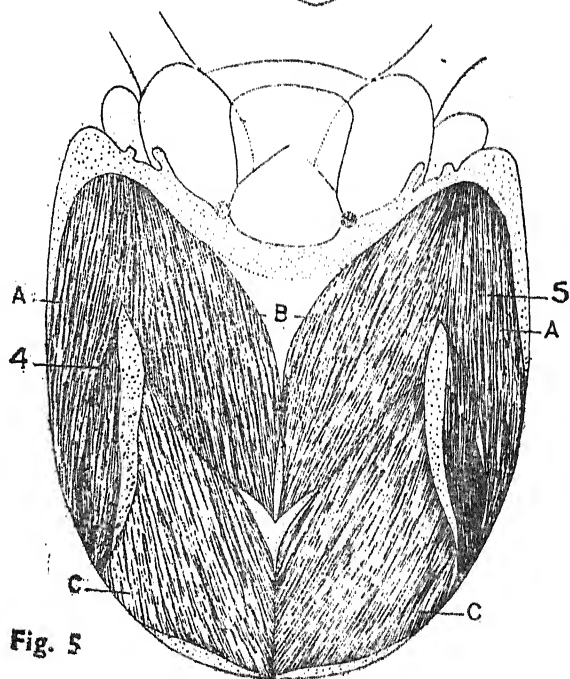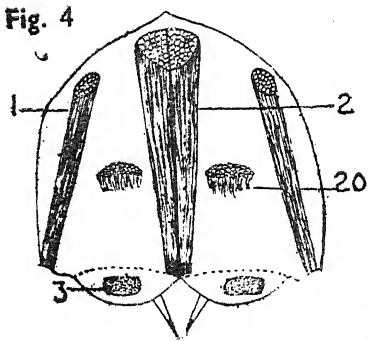
Fig. 5
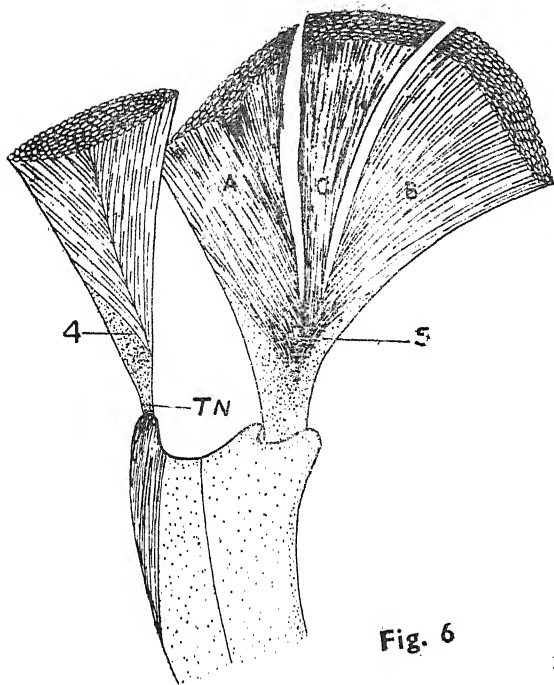
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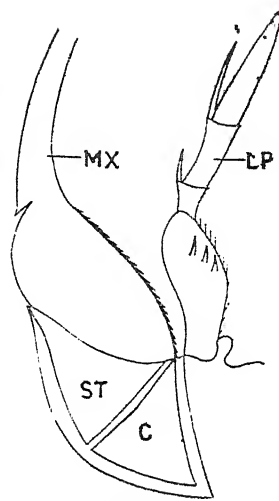
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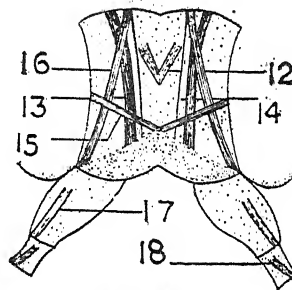
Fig. 8

Fig. 9
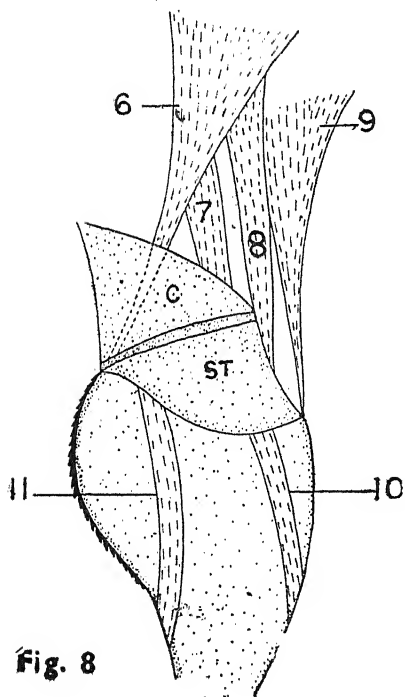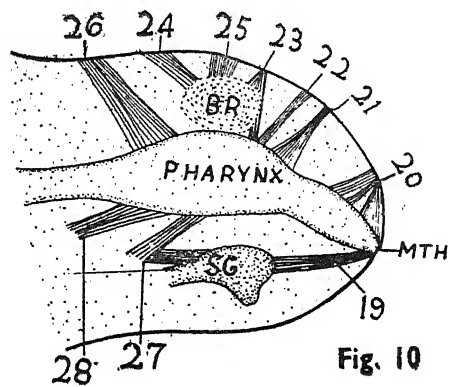
Fig. 10

Discussion

The presence of mesal mandibular flexor muscle and absence of ventral adductors in the mandibles of *Myrmeleon* larva suggests that its mandibles are essentially of orthopteroid type. Further evaluation of their morphological and evolutionary status, however, involves the consideration of all the types of mandibles met with among different neuropterous larvae ; generally two types of mandibles are found, straight type and curved type. The straight mandibles are found in the larvae of the members of the families, Ithonidae, Coniopterygidae, Osmylidae and Sisyridae. The curved and fang-like mandibles are present in the larvae of the members of the families Polystoecholisdae, Chrysopidae and Myrmeleonidae. According to Withycombe (1925) the two types of mandibles, straight and curved, represent two lines of evolution.

The curved jawed series is, however, regarded as primitive in comparision to the straight jawed series on the basis that the members with first type of mandibles have evolved concurrently with the habit of preying upon more active animals and their curved mandibles help them in providing a stable method of holding active prey.

The homology of the long maxillary blade which fits in the ventral mandibular groove to form a sucking canal, needs a careful evaluation. According to Tillyard (1917) the maxillary blade represents galea ; lacinia and palpus being absent. Crampton (1917) considered it to be the fused palpifer, palpus and galea of a normal maxilla. Withycombe (1925) regarded it to be the lacinia. To the present author also the maxillary blade of *Myrmeleon* larva appears to be lacinia. This contention is based mainly on a comparison of the maxilla of *Myrmeleon* larva with that of *Sialis* in which the galea is very small and the lacinia is almost like that of the former.

Crampton (1917) regarded the labium as fused gular and mental regions. Withycombe (1925) considered the whole structure as only the labium. He further maintained that the labial plate of myrmeleonid forms is the fused mentum and eulabium ; the gular region has ceased to exist owing to the encroachment of gena. On the basis of the present studies the homologies of the different parts of labium of *Myrmeleon* larva may be evaluated as follows : since the insertion of the the proximal median ventral muscles is on the ventral aspect of the labial plate, the latter region belongs to prementum (Snodgrass, 1935). Further the origin of these muscles, as a rule, is from the postmentum (Snodgrass, 1935) hence the region from where they originate *i.e.* middle region of the labial plate, should be considered as the postmentum area of the latter. The facts mentioned, therefore, help us to infer that the labial plate of *Myrmeleon* larva is a composite structure formed by the fusion of pre-and post-mentum.

Summary

The head and mouth parts of the *Myrmeleon* larva along with their musculature have been described.

The homologies of cephalic appendages have been discussed.

Acknowledgements

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THE INFLUENCE OF DIFFERENT SOURCES OF NITROGEN ON THE GROWTH OF *CERCOSPORA* SPP.

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This paper deals with the influence of various inorganic and organic sources of nitrogen on the growth of *Cercospora hibiscina*, *C. withaniae* and *C. crotalariae*. The earlier paper (Thind and Mandahar, 1964) dealt with the effect of different carbon compounds on the growth of the same three *Cercospora* spp.

Materials and Methods

The materials and methods were the same as already described by the authors in their earlier paper (Thind and Mandahar, 1964).

The basal medium used throughout the present studies had the following composition : Dextrose, 20 g ; KH_2PO_4, 5 g ; $MgSO_4 . 7H_2O$, 0·5 g ; $Fe_2 (SO_4)_3 . 6H_2O$, 0·005 g ; and distilled water, 1000 ml. The basal medium was divided into various lots depending upon the number of nitrogen compounds to be studied and these lots were sterilized at 15 lbs per square inch steam pressure for 15 minutes. Various nitrogen compounds were dissolved separately in distilled water and were then added, after sterilization, separately and aseptically to the remainder of the various lots of the basal medium. Each nitrogen compound was used in amount calculated to give 693 mg. of nitrogen per litre which amount is present in 5 g of KNO_3 per litre of the basal medium.

Potassium nitrite was used as the sole source of nitrogen in the basal medium when its effect on the growth of the fungi at different hydrogen-ion-concentrations was to be observed. The basal medium was divided into 10 lots and their pH was adjusted with Beckman pH meter, after sterilization, to 3·0, 4·0, 5·0, 6·0, 7·0, 8·0, 9·0, 10·0, 11·0 and 12·0 respectively by the addition of KOH or HCl.

Standardized mycelial suspension was used as inoculum for each fungus and this was prepared in the same way as already described by the authors in their earlier paper.

Experimental Work

Thirty-one nitrogenous compounds comprising 7 inorganic and 24 organic (22 amino acids and 2 amides) compounds were tested as sole sources of nitrogen for the growth of the three *Cercospora* spp. The data on dry weight and final pH were collected as usual and are summarized in Table I–III below.

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TABLE I

Effect of different inorganic nitrogen sources used singly on the growth of C. hibiscina
and C. withaniae *after 24 days incubation at 28°C and on the growth of*
C. crotalariae *after 12 days incubation at 26°C, initial pH adjusted to 6·0*

Nitrogen source	C. hibiscina		C. withaniae		C. crotalariae	
	Dry wt., mg	Final pH	Dry wt., mg	Final pH	Dry wt., mg	Final pH
Control (No nitrogen)	0	6·0	0	6·0	0	6·0
Potassium nitrate	180	6·4	175	6·4	190	6·4
Sodium nitrate	192	6·7	168	6·7	184	6·4
Potassium nitrite	0	6·0	0	6·0	0	6·0
Ammonium nitrate	146	2·8	164	3·0	145	3·1
Ammonium sulphate	154	2·8	158	3·0	152	3·0
Ammonium chloride	132	3·0	168	3·0	148	3·0
Ammonium phosphate	176	3·8	180	4·7	164	4·6

Inorganic Nitrogen Sources :

The data summarized in Table I indicate that none of the three fungi made any growth on potassium nitrite and in the absence of nitrogen while all of them made good growth on potassium nitrate, sodium nitrate, ammonium sulphate and amm·nium phosphate. Ammonium nitrate and ammonium chloride supported good growth of *C. withaniae* but fair of *C. hibiscina* and *C. crotalariae*. Out of the four ammonium salts used, ammonium phosphate supported better growth of these fungi than the other three ammonium salts.

The growth of all the three fungi resulted in a little rise in a final pH of media containing potassium nitrate and sodium nitrate, while it resulted in conspicuous fall in final pH in medium containing any one of the four ammonium salts. However, the fall in final pH was less with ammonium phosphate than with other three ammonium salts.

TABLE II

Effect of hydrogen-ion concentration on the utilization of KNO_3 *by* C. hibiscina *and*
C. withaniae *after 24 days incubation at 28°C and by* C. crotalariae *after*
12 days incubation at 26°C

Initial pH	C. hibiscina		C. withaniae		C. crotalariae	
	Dry wt., mg.	Final pH	Dry wt., mg	Final pH	Dry wt., mg.	Final pH
3	0	3·0	0	3·0	0	3·0
4	0	4·0	0	4·0	0	4·0
5	0	5·0	0	5·0	0	5·0
6	0	6·0	0	6·0	0	6·0
7	12	7·4	125	7·5	155	7·5
8	16	7·4	130	7·9	124	7·9
9	15	7·5	112	8·4	100	8·0
10	8	8·4	80	8·5	76	8·4
11	0	8·6	5	8·6	16	8·7
12	0	9·5	0	9·5	0	9·5

TABLE III

Effect of different organic sources of nitrogen used singly on the growth of C. hibiscina and C. withaniae after 24 days incubation at 28°C and on the growth of C. crotalariae after 12 days incubation at 26°C, initial pH adjusted to 6·0

Nitrogen source	C. hibiscina		C. withaniae		C. crotalariae	
	Dry wt., mg	Final pH	Dry wt., mg	Final pH	Dry wt., mg	Final pH
Control (No nitrogen)	0	6·0	0	6·0	0	6·0
Glycine	215	6·4	115	6·2	204	5·8
Dl–α–alanine	215	6·3	200	6·1	265	6·1
β–alanine	256	7·0	90	5·9	195	5·5
Dl-valine	168	5·8	98	5·7	180	5·2
Dl–norvaline	74	5·9	16	5·8	166	5·6
L–leucine	75	5·3	60	5·0	138	5·0
Dl–leucine	73	5·3	55	5·0	140	5·0
D+leucine	56	6·1	55	5·1	45	5·0
Dl–serine	214	6·5	160	5·9	180	6·2
Dl–threonine	155	5·8	110	5·8	224	5·6
Dl–aspartic acid	246	7·5	190	7·2	225	7·4
L–glutamic acid	238	7·0	225	7·2	235	7·0
Dl–lysine mono HCl	220	4·0	62	4·9	182	3·0
L–lysine HCl	210	4·1	65	4·5	170	3·0
L–arginine mono HCl	195	5·1	120	5·8	75	3·5
L–cystine	40	5·4	34	5·5	112	5·2
Dl–methionine	85	4·8	40	4·9	115	4·2
Dl–β–phenylalanine	125	5·9	73	5·8	78	5·3
L–proline	205	6·1	90	6·2	228	5·5
L–tryptophane	210	5·8	97	6·1	125	6·4
L–histidine mono HCl	155	6·1	196	6·1	195	3·5
Dl–histidine	156	6·1	192	6·1	170	3·5
L–asparagine	218	7·2	140	6·3	195	6·2
Urea	200	7·0	98	6·9	124	7·0

Effect of hydrogen-ion-concentration on the utilization of KNO_2 :

It is clear from the results summarized in Table II that none of the three fungi under study made any growth on the acidic pH range of 3·0-6·0 while they made poor, fair or good growth on the alkaline pH range of 7·0-11·0. Thus *C. hibiscina* made poor growth at pH 7·0-10·0 and none at pH 11·0 and 12·0 ; *C. withaniae* made fair growth at pH 7·0-10·0, poor at 11·0 and no growth at 12·0 ; *C. crotalariae* made good growth at pH 7·0, fair at pH 8·0-10·0, poor at 11·0 and no growth at 12·0,

Organic Nitrogen Sources :

It is clear from Table III that Dl-α-alanine, Dl-serine, Dl-aspartic acid, L-glutamic acid, Dl-histidine and L-histidine were all good sources of nitrogen for the growth of the three fungi under study. Glycine, β-alanine, Dl-valine, Dl-threonine, L-proline and L-asparagine were all good for *C. hibiscina* and *C. crotalariae* but fair for *C. withaniae*. L-and Dl-leucine were fair for *C. hibiscina* and *C. crotalariae* but poor for *C. withaniae*. L- and Dl-lysine were good for *C. hibiscina* and *C. crotalariae* but poor for *C. withaniae*. L-tryptophane and urea were good for *C. hibiscina* but fair for *C. withaniae* and *C. crotalariae*. Dl-norvaline was good for *C. crotalariae*, fair for *C. hibiscina* and poor for *C. withaniae*. D+leucine served only as a poor source of nitrogen for the growth of all the three fungi, while Dl-β-phenylalanine supported their fair growth. L-arginine was good for *C. hibiscina* but fair for *C. crotalariae* and *C. withaniae*. L-cystine was fair for *C. crotalariae* but poor for the other two. Dl-methionine was fair for *C. hibiscina* and *C. crotalariae* but poor for *C. withaniae*.

Discussion

All the three fungi studied here made good growth on the potassium nitrate and sodium nitrate. An enormous number of fungi worked out by many workers have been reported to utilize nitrates well. However, some fungi such as *Penicillium digitatum* (Fergus, 1952), *Schizophyllum commune* (Swack and Miles, 1960), *Thraustochytrium* spp. (Goldstein, 1963), and others either cannot utilize nitrates or utilize them only poorly.

All the three fungi under study made fair to good growth on the various ammonium salts used. An overwhelming majority of the fungi are reported to use ammonium nitrogen well. There are only a few fungi such as *Coprinus lagopus* and *Pleurotus corticatis* (Leonian and Lilly, 1938), *Blastocladiella emersonii* (Barner and Cantino, 1952), *Sapromyces elongatus* (Golueke, 1957) and *Phytophthora fragariae* (Davies, 1959) which have been reported to be unable to utilize ammonium nitrogen.

The growth of the fungi on ammonium salts as the nitrogen source is closely related to the fall of pH of medium as a result of ultization of the ammonium ion. Cochrane (1958) states : "One of the best established physiological correlates of ammonium assimilation from such salts as the sulphate, nitrate or chloride is the rapid and often quantitatively large drop in pH consequent upon preferential utilization of the cation." This large fall in pH can drastically reduce and even entirely stop the growth of the fungi. Many such fungi have been listed by Cochrane (1958). On the other hand, Pai (1953) reported a gradual and slow fall in pH on ammonium sulphate medium by the growth of *Fusarium vasinfectum* and *F. moniliforme*. However, this slow fall in pH allowed considerable growth of the fungi before it reached the inhibitory level. This probably also holds good for the three *Cercospora* spp. studied here, where fair to good growth of them may be consequent upon the presumable steady but slow fall in pH before it reaches the inhibitory level of 2·8 or 3·0 on the ammonium sulphate, chloride and nitrate media.* However, the fall in final pH with ammonium phosphate is not so great (pH 3·8, 4·7 and 4·6 in the case of *C. hibiscina*, *C. withaniae* and *C. crotalariae* respectively) with the result that this supports better growth of these fungi than the other three ammonium salts.

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*That the pH shifts in the case of three *Cercospora* spp. are gradual on media containing ammonium salts is dealt fully in a separate paper entitled "Utilization of ammonium nitrogen by the fungi" which is being sent to the Press soon.

None of these three fungi made any growth on potassium nitrite as the sole source of nitrogen at their optimum pH values (6.0). Fungi, in general, do not utilize nitrite for growth at their usual optimum pH values, which are generally below 7·0. However, a number of fungi have been reported to make poor, fair or even good growth on nitrite and some of these have been listed by Cochrane (1958). Some other recently reported such fungi are *Fusarium coeruleum* (Tandon and Agarwal, 1953), *Gloeosporaium psidii* and *G. piperatum* (Thind and Rawla, 1959) and *Cercospora viticola* (Sethi and Munjal, 1963).

The toxicity of nitrite to the growth of fungi is related to pH of the medium. Nitrites are generally toxic on the acidic pH range because at this range the nitrites exist in the form of undissociated nitrous acid which exerts the toxic effect because of its destructive influence on the proteins and amino acids of the fungal cells (Cochrane and Coon, 1950 ; Lilly and Barnett, 1951 ; Foster, 1949 ; Cochrane, 1950 and 1958)· All the three fungi under study could not make any growth at pH 3·0-6·0 but made poor, fair or even good growth at pH 7·0 to 10·0 on potassium nitrite as the sole nitrogen source. Similar results have also been reported by some other workers like Tandon and Agarwal (1953) with *Fusarium coeruleum*, Thind and Duggal (1957) with *Colletotrichum gloeosporioides* and Thind and Rawla (1959) with three anthracnose fungi.

Glycine, Dl-α-alanine, serine, aspartic acid, glutamic acid, proline, and asparagine were good or farily good sources of nitrogen for the growth of these three fungi. Many other fungi have also been reported to make good or fairly good growth on these. However, fungi growing poorly on these nitrogen sources are also known. Thus aspratic acid supports poor growth of *Gloeosporium papayae*, *G. musarum* and *Colletotrichum papayae* (Tandon and Grewal, 1956) ; glutamic acid of *Alternaria ricini* and *Phomopsis vexans* (Pawar and Patel, 1957a and b) ; L–asparagine of some Hymenomycetes (Yusef, 1953) ; Dl-α-alanine of *Tilletia caries* (Zscheile, 1951) ; Dl-serine of *Chalara quercina* (Beckman *et al*, 1953) and *Tilletia caries* (Zscheile, 1951).

L–cystine supported poor growth of *C. hibiscina* and *C. withaniae* but fair of *C. crotalariae* studied here. Dl-methionine supported poor growth of *C. withaniae* but fair of the other two fungi studied here. Dl-β-phenylalanine supported fair growth of all these three fungi. All these three have generally been regarded to be poor sources of nitrogen for the growth of majority of the fungi studied so far. However, some fungi are known to make good growth on cystine and methionine such as *Polychytrium aggregatum* (Ajello, 1948). Similarly, Dl-β-phenylalanine supports good growth of *Cercospora kikuchii* (Bloss and Crittenden, 1960) and the three anthracnose fungi studied by Tandon and Grewal (1956) and Thind and Rawla (1959) respectively.

L-and Dl- histidine, Dl-valine and Dl-threonine were fair to good sources of nitrogen for the growth of these three fungi. Some other fungi have also been reported to make fairly good growth on these.

Summary

Growth of three *Cercospora* spp. (*C. hibiscina* from *Hibiscus cannabinus*, *C. withaniae* from *Withania somnifera* and *C. crotalariae* from *Crotalaria juncea*) was studied on different nitrogen sources used singly. All the inorganic nitrogen sources used support good or fairly good growth of the three fungi under study except KNO_2 which did not support any growth. The growth of these fungi on KNO_2 as the sole nitrogen source was found to be conditioned by the pH of the medium. These fungi could utilize nitrite only on the alkaline range of pH 7·0 to 10·0 and

hot on the acidic pH range of 3·0 to 6·0. Out of the organic sources of nitrogen used, Dl-α-alanine, Dl-serine, Dl-aspartic acid, L-glutamic acid, L- and Dl-histidine, asparagine, glycine, β-alanine, Dl-valine, Dl-threonine and L-proline supported good or fairly good growth of these three fungi. The rest of the organic sources of nitrogen yielded variable growth i.e., poor, fair or good.

Acknowledgements

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ECOLOGY OF THE SOIL FUNGI OF SOME GRASSLANDS OF VARANASI* I EDAPHIC FACTORS AND FUNGI

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Introduction

The study of fungi from various types of soils has engaged the attention of a large number of workers in different parts of the world and in India but the ecological aspects, governing their distribution in soils, have been investigated only by a few workers (Warcup 1951, Garrett 1950, 1951, 1952, Park 1955, Orpurt and Curtis 1957, Hawker 1957, Parkinson and Waid 1960). In India the work on such aspects is very fragmentary which is mainly by Saksena (1955) and Saksena and Sarbhoy (1963) from forest and alluvial soils respectively. As no attempt has been made on ecology of soil fungi occurring in association of different natural grasslands in this country, the present work has been undertaken. This study includes, besides isolating and identifying fungi, phytosociological analysis of fungi and study of the edaphic factors affecting their appearance and growth in soils.

Soil and Climate

Varanasi lies at 25°18'N. Lat. and 83°1'E. Long. in the eastern part of the Upper Gangetic Plain and is about 77 meters above the sea-level. The soil is alluvium and its texture ranges from sand to clay. The old alluvium contains local deposits of calcium carbonate in the form of nodules known as "Kanker". The climate is typical of the upper gangetic plains, distinctly continental and shows a great range of temperature between summer and winter. The year is divided into three distinct seasons *viz.*, rainy, winter and summer seasons with annual rainfall of about 1100 mm.

Materials and Methods

I. Grass plots selected for the study

The following grass plots were selected for the study of soil fungi :

    (1) *Desmostachya bipinnata* Stapf—*Cynodon dactylon* Pers. association.

    (2) *Vetiveria zizanioides* Nash.—*Dichanthium annulatum* Stapf association.

    (3) Stands of *Saccharum spontaneum* Linn. with some annual weeds.

The above grass plots are situated in the Botanical Garden of the Banaras Hindu University campus The distance between the plots is ninety feet and all lie on the same straight line. The soil fungi were studied in the summer season. The soil is Gangetic alluvium and each plot supports different surface vegetation.

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*Based on the thesis approved for the degree of Doctor of Philosophy of Banaras Hindu University.

(4) *Setaria glauca* Beauv.—*Dichanthium annulatum—Oplismenus burmannii* P. Beauv. association. This plot is situated in Bhadohi sub-division at a distance of forty miles West of Varanasi proper. The soil is alkaline as the pH ranges between 7·5–8·5.

(5) *Dichanthium annulatum—Cynodon dactylon—Cyperus* sp. association. This grass plot is situated in Chandauli sub-division about thirty miles East of Varanasi proper. The pH of the soil here ranges from 6·6–6·7.

(6) Stands of *Vetiveria zizanioides*. This grass plot is situated in sub-division Chakia about fifty-five miles towards South-East of Varanasi proper. The area is surrounded by hillocks. It is a low-lying area and remains submerged under water for about four or five months in a year between July and November.

II. *Method of taking soil samples and recording of fungal flora*

Soil samples were taken aseptically by digging a pit of $1' \times 1' \times 2'$ dimension and cutting the steps at intervals of $6''$. Three samples from the depths of 0–$6''$, $6''$–$12''$ and $12''$–$18''$ were taken in separate sterilized containers and were marked as S^1, S^2 and S^3 soils respectively. For replication three such pits were dug and samples were taken from them in the same manner. Soil samples were brought to the laboratory and their pH and moisture contents were determined immediately. Soils of the respective depths were mixed thoroughly in sterilized mortars and soil solutions of three grades *viz.*, 1 : 100, 1 : 1000 and 1 : 10,000 were prepared with sterilized water. 1 cc. solution from each grade was transferred to a set of six Petri plates and eighteen plates were prepared for each sample. Thus the total of fifty-four for one pit and one hundred and sixty-two plates were prepared from the samples taken from the three pits. Separate sterilized pipettes were used to transfer soil solutions to Perti plates and about 10 cc. of sterilized molten peptone-dextrose agar+rose bengal at 40°C were added to each plate by shaking them so as to disperse the solution uniformly. Petri plates were incubated at 25°C for a week. The fast growing colonies were transferred to fresh culture tubes or fresh agar plates to avoid overrunning of other colonies by such fungi.

After a week the number of colonies in each plate was counted and the number of fungi per gram of soil was determined by multiplying the numbers by actual dilutions. The average number was counted by taking into consideration moisture content of soils.

III. *Phytosociological study of plants and fungi*

(i) *Surface vegetation.*—The grass plots were studied phytosociologically in quadrats of 1×1 meter in size and the dominant and sub-dominant grasses and other weeds, growing along with them, were noted down.

(ii) *Determination of Frequency and Abundance of fungi.*—After the species were finally identified, the preserved Petri plates were taken out of the refrigerator. Each plate was considered as a unit of study just like a quadrat in the phytosociogical study of higher plants. Frequency and abundance in different horizons from different sets of dilution plates were determined as per method of Saksena (1955).

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IV. Determination of Physico-Chemical Characteristics of soils

Soils were tested and analysed for their physico-chemical characters such as the pH value, moisture content, water-holding capacity, organic matter, carbon content, carbonate content, available nitrogen, nitrate, phosphate, exchangeable calcium, potassium, sodium and magnesium. pH of the soil samples was determined by Beckman's pH meter. Moisture content, water-holding capacity and organic matter content were determined by the methods as given by Piper (1944). Exchangeable calcium, potassium, sodium and magnesium were determined by the methods suggested by Mehlich (1948). The soil leachates were prepared for this method by leaching the soil with replacement solutions A and B. Sodium and potassium were estimated by Flame Photometer ; magnesium by Beckman's Spectrophotometer and calcium by Volumetric method titrating against the standard solution of $KMnO_4$. Available nitrogen was estimated by the method adopted by Subbiah and Asija (1956). Nitrate content was estimated by Phenol-disulphonic acid method as recommended by Harper (1924). Carbonate was estimated by Collin's calcimeter modified by Shah and Amin (1951). The organic carbon was determined by multiplying the percentage of humified material (organic matter) with the arbitrary factor 0·58. Available phosphate was determned by the methods of Puri and Asghar (1936) and Chapman (1932).

Obervations

(1) Physico-chemical characters of soils are given in table I.

(2) Details of surface vegetation along with important soil characters and phytosociological analysis of fungal flora of each grass plot are being described below :

Grass Plot I

Surface vegetation.—The plot is covered with luxuriant growth of *Desmostachya bipinnata* Stapf as a dominant grass which grows upto a height of one to one and half meters. The rhizomes of the grass with its branches grow horizontally from which roots and rootlets arise and penetrate into the deeper layer of the soil. The roots were recorded upto a depth of twenty-four inches. *Cynodon dectylon*, the sub-dominant grass, grows luxuriantly among the patches of the dominating one. *Evolvulus alsinoides* Linn. and the sub-dominant serve as the filler among the patches of the dominating grass. Nothing else was found to grow.

*Physical characteristics of soils :

Soil S^1 .. Reddish brown (5 YR 4/4)** when wet and Reddish brown 5 YR 5/4 when dry ;

Moisture content and water-holding capacity are 8·95% and 52·6% respectively.

Soil S^2 .. The colour and texture of the soil are as above ; moisture content and water-holding capacity are higher than the above soil, the smell is earthy.

Soil S^3 .. The colour and texture are the same as in S^2, moisture content is higher and water-holding capacity is lower than the S^2 soil

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*For the comparison of soil characters refer to Table I.
**Names and notations of colour described in the text are according to Munsell notation for soil colour chart.

Chemical characters.—The soil is slightly alkaline with pH 7·1 in S¹ and S³ soils while in S² soil it is a little acidic (pH 6·8) ; organic matter and organic carbon contents are higher in S² than in S¹ and S³. Available nitrogen is higher in S² soil. The amount of exchangeable calcium is higher. The exchangeable sodium is less and exchangeable potassium is higher than sodium throughout the profile.

Record of fungal flora :

(*i*) Average number of fungi per gram of dry soil (S¹)–70,000 (S²)–76,666 (S³)–26,666.

(*ii*) Species isolated :

	*Name of species	S¹		S²		S³	
		F	A	F	A	F	A
1.	*Rhizopus nigricans*	3	2	2	2	2	2
2.	*Mucor luteus*	4	3	–	–	–	–
3.	*M. circinelloides*	2	2	–	–	–	–
4.	*M. oblongisporus*	2	2	3	2	–	–
5.	*M. saturninus*	3	2	–	–	–	–
6.	*Syncephalastrum racemosum*	3	3	4	3	–	–
7.	*Eremascopsis spinosa* gen. *et* sp. nov.	–	–	1	4	–	–
8.	*Neocosmospora vasinfecta*	5	3	3	2	–	–
9.	*Pestalotia* sp.	1	2	1	3	–	–
10.	*Trichoderma viride*	3	2	2	2	2	2
11.	*Aspergillus nidulans*	4	4	3	2	–	–
12.	*A. niveus*	4	3	3	3	–	–
13.	*A. terreus*	4	2	4	3	2	1
14.	*A. niger*	4	2	3	3	3	2
15.	*A. awamori*	2	3	4	2	–	–
16.	*Penicillium javanicum*	5	3	3	2	3	3
17.	*P. funiculosum*	5	3	2	2	–	–
18.	*Cladosporium herbarum*	4	3	3	2	–	–
19.	*Stysanus medius*	3	2	5	3	3	2
20.	*Curvularia lunata*	2	3	1	2	–	–
21.	*Alternaria humicola*	1	3	2	2	–	–
22.	*Humicola fusco-atra*	3	2	1	3	–	–
23.	*Epicoccum duriaenum*	1	2	–	–	–	–
24.	*Colletotrichum falcatum*	3	2	–	–	–	–

*Authorities for all the binomials of fungi are as given by Gilman (1957), Thom and Raper (1945), Raper and Thom (1949) and Saccardo (1884). Authorities for such species which are not given in these books, are mentioned in footnote, at appropriate places.

F = Frequency   A = Abundance.

Outstanding characters of the fungal flora.—The plot is rich in fungal population both in number of species and total quantity per gram of soil. The members of the Mucorales were confined mostly to the top horizon. Only *Rhizopus nigricans* was distributed throughout the profile. Fungi mostly isolated throughout the profile were *Trichoderma viride, Aspergillus niger, A. terreus, Penicillium javanicum* and *Stysanus medius.* Only six species were distributed in the lowest horizon. The top horizon was very rich in the fungal flora. One new fungus, *Eremascopsis spinosa* gen. *et* sp nov., was discovered from the middle horizon. The remarkable point to be noted is the greater number of fungi per gram of soil in the middle horizon.

Glass Plot II

Surface vegetation.—The plot is characterized by supporting the growth of *Vetiveria zizanioides* Nash. as a dominant species. It grows upto several feet in height (5–8 feet). *Dichanthium annulatum, Cynodon dactylon* and *Evolvulus alsinoides* grow among the patches of the dominating grass. These grasses grow very luxuriantly. Roots were recorded upto forty inches deep.

Physical characteristics of soils :

Soil S^1 .. Colour of the soil is light yellowish-brown (10 YR 5/4) when wet and yellowish-brown (10 YR 6/4) when dry ; texture Gangetic alluvium ; mixed with roots and rootlets of the dominating grass ; smell pleasant ; water-holding capacity is 43·5% ; with cracks when dry.

Soil S^2 .. Colour of the soil is same as above both in dry and wet conditions ; texture loamy with clay ; mixed with roots and rootlets of the dominating grass ; smell pleasant ; water-holding capacity is slightly higher than the above soil.

Soil S^3 .. Colour of the soil is same as above (S^2) both in dry and wet conditions ; mixed with fine granules of pebbles ; texture loamy ; coarse to touch ; smell pleasant ; mixed with roots and rootlets of the dominating grass ; water-holding capacity is higher than that of both the above soils.

Chemical characters.—pH of soil is the same throughout the profile, being 7·1 ; organic matter is higher in the middle horizon than in the top and lowest ones ; carbon content is not much, its value increases in middle horizon and decreases in the lowest one ; exchangeable calcium goes on increasing according to increase in depth and its value is maximum in the lowest horizon ; exchangeable sodium and potassium contents are slightly higher than in the soils of the first type of grass plot. Exchangeable potassium is maximum in the lowest level. Nitrate content is in good amount throughout the profile.

Record of fungal flora :

(i) Average number of fungi per gram of dry soil. (S¹)–30,000 (S²)–23,809 (S³)—8,231.

(ii) Fungi isolated :

Name of species	S¹		S²		S³	
	F	A	F	A	F	A
1. Rhizopus nigricans	3	2	3	3	—	—
2. Mucor luteus	4	3	—	—	—	—
3. Thielavia terricola	5	2	3	1	—	—
4. Neocosmospora vasinfecta	5	4	5	2	—	—
5. Trichoderma viride	5	3	4	3	4	2
6. Aspergillus nidulans	5	3	3	2	—	—
7. A. variecolor	4	4	4	2	—	—
8. A. terreus	5	4	5	3	3	1
9. A. candidus	2	1	3	2	—	—
10. A. niger	4	2	3	2	1	2
11. A. flavus	4	4	2	2	—	—
12. A. sydowi	—	—	3	3	—	—
13. A. japonicus	3	2	—	—	—	—
14. A. sulphureus	4	3	—	—	—	—
15. Aspergillus sp.	5	3	—	—	3	2
16. Penicillium humicola	4	2	—	—	3	1
17. Penicillium sp.	2	1	—	—	—	—
18. P. funiculosum	—	—	2	2	—	—
19. Cephalosporium coremioides	3	3	2	1	—	—
20. Paecilomyces varioti	2	3	2	1	4	2
21. *P. fusisporus	5	3	—	—	—	—
22. Cladosporium herbarum	3	3	3	2	—	—
23. Alternaria humicola	4	3	2	3	—	—
24. Helminthosporium anomalum	2	2	3	1	—	—
25. Curvularia lunata	3	3	2	3	—	—
26. Fusarium nivale	4	3	3	3	2	2

Outstanding characters of the fungal flora.—The plot was rich in fungal flora. Aspergilli were in abundance and mostly confined to the top and the middle horizons. Only *Aspergillus niger*, *A. terreus* and *Aspergillus* sp. were isolated from the lowest horizon. Ascomycetes were represented by (including ascosporic *Aspergillus*) *Aspergillus nidulans*, *A. variecolor*, *Neocosmospora vasinfecta* and *Thielavia terricola*. The fungi present throughout the profile were *Trichoderma viride*, *Aspergillus terreus*, *A. niger*, *Paecilomyces varioti* and *Fusarium nivale*.

*P. fusisporus Saksena.

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Grass Plot III

Surface vegetation.—The plot is full of profused growth of *Saccharum spontaneum* as a dominant grass. *Cynodon dactylon* grows underneath the latter in the bare spaces. Other weeds growing along with these grasses are *Evolvulus alsinoides* and *Polygonum plebejum* Br. Roots of the dominant grass were recorded upto a depth of 25 inches.

Physical characters of soils.—Colour reddish-brown (5 YR, 5/4) when dry and reddish-brown (5 YR, 4/4) when wet ; texture loamy with cracks when dry, mixed with small pieces of pebbles and roots of dominant grasses. Water-holding capacity and moisture contents vary at different horizons. Other physical characters are the same in different horizons.

Chemical characters.—Soil is slightly alkaline as pH ranges from 7·1–7·2 ; organic matter is higher in the top soil and decreases below ; carbonate content increases with depth ; exchangeable calcium is well distributed and is the highest in the top layer ; exchangeable sodium and potassium are more in the middle horizon. Nitrate content is in good amount throughout the profile but decreases as the depth increases. Its value is lower than in the first and the second grass plots.

Record of Fungal Flora :

    (*i*) Average number of fungi per gram of dry soil. (S^1)–19,717, (S^2)–9,700 (S^3)–9,203.

    (*ii*) Fungi isolated :

	Name of species	S^1 F	S^1 A	S^2 F	S^2 A	S^3 F	S^3 A
1.	*Rhizopus nigricans*	2	2	2	1	–	–
2.	*Mucor* sp.	1	2	–	–	–	–
3.	*Chaetomium terrestre* sp. nov.	–	–	–	–	1	2
4.	*Royella albida* gen. *et* sp. nov.	1	3	–	–	–	–
5.	*Neocosmospora vasinfecta*	4	2	3	4	–	–
6.	*Trichoderma viride*	4	3	3	3	2	2
7.	*Aspergillus nidulans*	3	2	2	2	–	–
8.	*A. variecolor*	4	2	3	3	–	–
9.	*A. niveus*	–	–	1	3	2	3
10.	*A. candidus*	4	4	–	–	–	–
11.	*A. terreus*	5	3	3	3	–	–
12.	*A. niger*	5	2	2	4	4	2
13.	*A. sulphureus*	1	3	–	–	–	–
14.	*Penicillium raistrickii*	4	2	–	–	–	–
15.	*P. funiculosum*	5	2	3	3	–	–
16.	*P. spiculisporum*	–	–	3	2	–	–
17.	*Penicillium* sp.	1	3	–	–	–	–
18.	*Hendersonula toruloidea*	–	–	2	3	1	2

Name of species	S¹		S²		S³	
	F	A	F	A	F	A
19. *Paecilomyces fusisporus	3	2	2	2	—	—
20. Cephalosporium coremioides	3	2	3	3	—	—
21. Stachybotrys sp.	3	2	3	1	—	—
22. *Phialophora richardsiae	—	—	2	4	4	3
23. Cladosporium herbarum	2	3	—	—	—	—
24. *Helminthosporium halodes	2	3	—	—	—	—
25. Spegazzinia tessarthra	3	2	1	3	—	—
26. Scolecobasidium constrictum	—	—	—	—	1	3
27. Epicoccum duriaenum	2	4	3	2	—	—
28. *Myrothecium verrucaria	5	4	2	3	—	—
29. *Fusarium chlamydosporum	4	2	—	—	—	—
30. Mycelia sterilia	5	4	2	2	—	—

The fungal flora was less in number per gram of soil in all the horizons than in those of other plots but variety of species was greater. The predominant species in the top were *Neocosmospora vasinfecta, Aspergillus niger, A. candidus, A. terreus, Penicillium raistrickii, P. funiculosum, Myrothecium verrucaria, Mycelia sterilia* and *Fusarium chlamydosporum*. Only a few species were isolated from the lowest horizon. A new species of *Chaetomium* was isolated from this plot. Several forms such as Nos. 18, 22 and 26 were isolated for the first time in India. Besides, a new genus *i.e.*, *Royella albida* was discovered from this plot.

Grass Plot IV

Surface vegetation.—The dominant grasses are already mentioned and others coming second in order of frequency and dominance are *Dichanthium annulatum, Eragrastis tenella* Roem. et Schult., *Dactyloctenium aegypticum* Beauv., *Cassia tora* L., *Evolvulus alsinoides* L., *Euphorbia hirta* L., *E. thymifolia* L., *Polygella chinensis* L. and *Desmodium triflorum* DC.

Physical characters of soils.—Colour of soils is light-brown (2·5,Y, 5/4) when wet and light-grey with whitish-tinge (5Y, 7/2) when dry; texture loamy, mixed with pebbles, sticky when wet, water-holding capacity is higher in S² soil than that of S¹ and lower in S³ soil. Other characters are similar throughout the depths.

Chemical characters.—The soil throughout the profile is alkaline as the pH varies between 7·5–8·6; the amount of organic matter is the highest in the top layer and its value decreases with depth. The amount of exchangeable calcium is high in the top horizon, decreases in the middle layer and again slightly increases in the lowest horizon. Exchangeable sodium content is very high but increases with an increase in depth. Exchangeable potassium content is about the same throughout the profile. Nitrate content is in fair amount throughout the profile.

Note.—Authorities naming 18, 22, 25 and 28 are Nattrass, (Nanff.) Conant (Brek. & Cort.) Sacc. and Ditmar ex Fr. respectively.

*Species deposited in the Commonwealth Mycological Institute, Kew, England.

Record of fungal flora :

(i) Average number of fungi per gram of dry soil. (S^1)–44,418 (S^2)–22,560 (S^3)–9,427.

(ii) Fungi isolated :

Name of species	S^1		S^2		S^3	
	F	A	F	A	F	A
1. Rhizopus nigricans	3	4	1	3	1	2
2. Mucor luteus	3	2	2	3	–	–
3. Cunninghamella verticillata	–	–	–	–	2	4
4. Saksenaea vasiformis	–	–	2	3	1	3
5. *Choanephora cucurbitarum	2	2	–	–	–	–
6. *Chaetomium funicola	5	2	4	3	–	–
7. Neocosmospora vasinfecta	1	2	–	–	–	–
8. Monilia geophila	3	4	2	2	–	–
9. *Aspergillus ruber	4	2	4	3	3	2
10. *A. nidulans	2	1	–	–	1	3
11. A. niveus	–	–	1	3	2	3
12. A. terreus	–	–	4	3	3	2
13. A. niger	5	3	3	2	3	2
14. Penicillium tardum	1	3	2	2	1	4
15. P. funiculosum	2	3	1	3	–	–
16. P. sanguineum	3	3	3	2	–	–
17. Gliocladium fimbriatum	1	5	–	–	–	–
18. *Calcarisporium pallidum	4	3	3	2	–	–
19. *Paecilomyces fusisporus	4	2	1	3	–	–
20. Trichothecium roseum	2	4	–	–	–	–
21. Trichoderma viride	4	2	3	1	–	–
22. Acrostalagmus cinnabarinus	–	–	–	–	1	3
23. Cladosporium herbarum	1	3	–	–	–	–
24. Spondylocladium australe	–	–	2	5	–	–
25. Nigrospora sphaerica	4	2	3	4	–	–
26. Scolecobasidium terreum	–	–	3	2	–	–
27. Memnoniella echinata	1	2	–	–	–	–
28. *Caldariomyces sp.	1	3	–	–	–	–
29. Helminthosporium halodes	3	4	2	2	–	–
30. Curvularia lunata	2	2	2	2	–	–

Note.—Authorities for naming the species 4, 5, 18, 26, 29 are Saksena, (Brek. & Br.) Thaxt., Tubaki, (Riv.) Galloway and Drechsler respectively.
*Species deposited in the Commonwealth Mycological Institue, Kew, England.

The number of fungi per gm. of soil decreased according to the increase in depth. The plot is rich both in total number and variety of species. Both the top and the middle layers are rich in fungal flora. Twenty-three forms were isolated from the top, twenty from the middle and ten forms were collected from the lowest horizon. Some forms such as Nos. 6, 7, 18, 23, 24, 25 and 27 were discovered only from this plot.

Grass Plot V

Surface vegetation.—Besides the dominant grasses already mentioned, other associates are *Echinochloa colonum* Link., *Digitaria sanguinalis* Scop., *Eragrastis tenella* and *Oplismanus Burmanni, Portulaca oleracea* L., *Crotalaria medicagenia* Lamk., *Bonnaya brachiata* Link., *Euphorbia hirta, E. thymifolia* and *Scoparia dulcis* L.

Physical characters of soils.—Clayey loam, colour is pale brown (10 YR, 6/3) when dry and brownish (10 Y, 5/3) when wet throughout the horizons.

Soil S¹ .. Mixed with rotten leaves of weeds, moisture content is high and water-holding capacity is comparatively low.

Soil S² .. Soil slightly coarser and gritty to touch, water-holding capacity is higher than that of S¹.

Soil S³ .. Mixed with small pebbles, sticky to touch, moisture content higher than S¹ and S² ; water-holding capacity is lower than in S².

Chemical characters.—The soil is slightly acidic in comparison to the soils of the other grass plots. The pH ranges between 6·6–6·7 throughout the profile ; organic matter and exchangeable bases are low, exchangeable calcium, sodium and potassium increase depthwise. The highest value of nitrate content is at the lowest horizon and remains constant in the middle and the top ones.

Record of fungal flora :

(i) Average number of fungi per gram of dry soil. (S¹)–54,500 (S²)–42,300 (S³)–28,266.

(ii) Fungi isolated :

	Name of species	S¹		S²		S³	
		F	A	F	A	F	A
1.	*Rhizopus nigricans*	3	2	2	2	—	—
2.	*Mucor luteus*	2	3	2	2	—	—
3.	*M. saturninus*	2	3	1	3	—	—
4.	*Cunninghamella verticillata*	5	3	1	3	1	3
5.	*Chaetomium spirale*	—	—	1	4	—	—
6.	*Neocosmospora vasinfecta*	3	4	2	2	—	—
7.	*Phoma hibernica*	3	3	3	2	2	2
8.	*Trichoderma viride*	3	3	3	2	2	2
9.	*Pestalotia monorhinca*	3	2	2	2	—	—
10.	*Aspergillus montevidensis*	5	3	2	2	—	—
11.	*A. nidulans*	—	—	3	4	—	—

Name of species	S¹		S²		S³	
	F	A	F	A	F	A
12. *A. fumigatus*	5	4	–	–	3	2
13. *A. niveus*	3	2	5	2	2	4
14. *A. terreus*	3	2	1	3	2	4
15. *A. niger*	5	3	5	2	2	4
16. *A. awamori*	3	3	3	3	–	–
17. *A. lutescens*	5	3	–	–	–	–
18. *A. flavus*	3	4	2	2	1	3
19. *Penicillium spiculisporum*	4	2	–	–	–	–
20. *P. funiculosum*	–	–	2	2	1	2
21. *Gliocladium roseum*	1	3	–	–	–	–
22. *Paecilomyces fusisporus*	–	–	2	3	–	–
23. *Botrytis cinerea*	1	2	–	–	–	–
24. *Papularia sphaerosperma*	4	3	–	–	–	–
25. *Cladosporium herbarum*	2	2	2	3	–	–
26. *Curvularia lunata*	2	1	3	4	–	–
27. *Alternaria humicola*	2	3	1	2	–	–
28. *Fusarium chlamydosporum*	4	3	–	–	–	–
29. *Fusarium nivale*	3	2	2	2	2	2

The plot is rich in total number of fungi per gm. of soil and variety of species. Most of the fungi were distributed in the top and the middle horizons. The top soil contained 25, the middle horizon harboured 22 and the lowest horizon contained 10 species. A few forms such as Nos. 5, 7, 10, 17, 21, 23 and 24 were recorded only from this plot.

Grass Plot VI

Surface vegetation.—Besides supporting the luxuriant growth of *Vetiveria zizanioides* as the dominant grass, *Eleocharis plantaginea* Br. is the associate being sub-dominant and serves as filler among the patches of the dominant one. The latter grows 8–10 feet high with well developed rhizomes and roots.

Physical characters of soils.—The soil is sandy with small pieces of stones. Colour is reddish-brown (5 YR, 4/3) in wet and dry conditions ; smell is pleasant due to presence of root fragments of the dominant grass (Khas).

Soil S¹ .. Fine sands mixed with little quantity of loam.

Soil S² .. Coarse sands, moisture content is greater and water-holding capacity is lower than S¹.

Soil S⁹ .. More standy, very coarse, colour reddish-brown (5 YR, 4/3) in dry and deep reddish-brown (5 YR, 3/4) in wet conditions ; moisture content is higher and water-holding capacity is lower than S².

Chemical characters.—The pH of the soils is the same (7·2) throughout the profile. The value of organic content is the highest at the top layer and decreases in deeper layers; exchangeable calcium is high but increases in the middle layer and decreases in the lowest horizon. Exchangeable sodium increases with depth and the highest value is reached in the lowest horizon. Exchangeable magnesium is the highest in the middle layer. The soil is well supplied with nitrate throughout the profile.

Record of fungal flora

    (*i*) Average number of fungi per gram of dry soil. (S^1)–16,329 (S^2)–18,237 (S^3)–6,245.

    (*ii*) Fungi isolated :

Name of species	S^1		S^2		S^3	
	F	A	F	A	F	A
1. *Rhizopus nigricans*	5	3	4	2	—	—
2. *Gongronella butleri* var. *proliferans* var. nov.	5	3	4	2	3	3
3. *Saksenaea vasiformis*	1	3	4	3	—	—
4. *Mucor luteus*	3	2	3	2	—	—
5. *Achlya sp.	*	—	—	—	—	—
6. *Thielavia terricola*	5	2	4	4	—	—
7. **Thielavia sp.	4	4	1	3	—	—
8. ***T. setosa*	4	5	2	3	—	—
9. *Chaetomium globosum*	3	2	—	—	—	—
10. *C. bostrychodes*	2	1	—	—	—	—
11. *Pestalotia* sp.	(1	3	3	2	—	—
12. *Aspergillus terreus*	4	4	4	3	—	—
13. *Aspergillus* sp. (new)	—	—	5	3	—	..
14. *Aspergillus niger*	3	2	—	—	—	—
15. ***Penicillium brefeldianum*	—	—	3	2	—	—
16. *P. funiculosum*	—	—	4	2	—	—
17. *Penicillium* sp.	1	2	—	—	—	—
18. *P. frequentans*	2	2	3	2	—	..
19. *Epicoccum duriaenum*	—	—	3	2	2	2

The number of fungi per gm. of soil was greater in the middle horizon and decreased abruptly in the lowest horizon. The number and variety were very low in comparison with other plots. In all, nineteen species were isolated. Fourteen were distributed both in the top and middle horizons and only two were isolated from the S^3 soil.

*Isolated from a water culture plate.
**Deposited in the Commonwealth Mycological Institute, Kew, England.

TABLE 1

Physico-chemical characters of soils (Based on average of three samples)

Grass plots	Hori-zons	pH	Moisture content %	W. H. C. %	Org. matter %	C. content %	CO₃ content %	Ava. N. %	NO₃ Mg. per 100 gm. of soil	Exch. Ca m.e. %	Exch. Mg m.e. %	Exch. Na m.e. %	Exch. K m.e. %	Phosphate parts per million	No. of Fungi per gm. of dry soils
I	S¹	7·1	8·95	52·6	0·9	0·522	0·4	0·008	12	5·34	0·22	0·26	0·94	3·2	70,000
	S²	6·8	9·74	55·3	3·2	1·856	0·18	0·022	10·6	5·64	0·2	0·3	0·98	3·2	76,666
	S³	7·1	10·94	53·6	0·19	0·11	0·08	0·019	8·5	4·98	0·206	0·66	0·88	3·1	26,666
II	S¹	7·1	7·2	43·5	0·93	0·539	0·03	0·001	9	6·7	0·193	1·68	1·02	3·1	30,000
	S²	7·1	7·5	44·2	1·2	0·696	0·26	0·015	9·6	6·7	0·193	0·48	0·72	3·0	23,809
	S³	7·1	8·7	47·6	0·21	0·121	0·04	0·001	9·7	7·4	0·18	0·68	1·06	3·0	8,231
III	S¹	7·2	7	44·6	2·9	1·682	0·26	0·019	8·4	8·6	0·186	0·6	0·7	2·8	19,717
	S²	7·1	8·6	40·9	2·4	1·392	0·46	0·12	8·2	8·84	0·2	1·16	0·84	2·2	9,700
	S³	7·1	8·6	37·1	1·7	0·986	0·49	0·19	7·3	6·84	0·2	0·96	0·64	2·2	9,203
IV	S¹	7·5	12·53	41·5	2·7	1·566	0·76	0·035	8	6·4	0·2	5·08	0·78	4	44,418
	S²	8	15	45·9	1·7	0·986	1·48	0·009	8·2	4·26	0·193	9·8	0·72	3·4	22,560
	S³	8·6	15·5	30·3	1·4	0·812	1·25	0·001	7	4·52	0·2	16·4	0·78	3·4	9,427
V	S¹	6·6	15·6	37·3	1·3	0·754	0·28	0·015	7·5	3·9	02·13	1	0·56	4·2	54,500
	S²	6·6	17·1	38·6	1·3	0·754	0·25	Trace	7·5	5·4	0·193	1·1	0·56	4·2	42,300
	S³	6·7	18·7	36·8	1·1	0·638	0·39	Trace	7·8	7·94	0·195	1·24	0·8	4·2	28,266
VI	S¹	7·2	14·6	45·6	2·5	1·45	0·22	0·021	5·4	6·5	0·213	1·9	1·04	3·1	16,329
	S²	7·2	15·9	38·9	1·3	0·754	0·15	0·014	6·5	8·1	0·24	5·76	0·26	3·0	18,237
	S³	7·2	18·3	33·2	1·3	0·754	0·32	Trace	6·5	6·74	0·173	8·28	0·42	3·0	6,245

W. H. C. = Water-holding Capacity.

Discussions and Conclusions

This investigation deals mainly with the types of surface cover, characters of soils and the nature and distribution of fungal flora. Soil factors governing the distribution of fungi are being discussed below :

Vertical distribution of fungi.— A perusal of Table I shows that the number of fungi per gm. of dry soil decreased with the increase in depth. This observation is in accord with those of Cobb (1932), Takahashi (1919) and Warcup (1951). From graph I it is clear that the number of fungi decreased from upper to lower layer except in plots I and VI where the number per gm. is greater in the middle horizon. This exception in case of the former may be explained as due to the greater value of water-holding capacity and to the higher percentage of organic matter, exchangeable Mg and K contents of the soil. Moreover, the rhizomes of the dominant grass, *Desmostachya bipinnata*, are very prominent in this horizon and their possible secretions may also be responsible for this increase. In plot VI water-logging condition may be responsible for the increase in fungal population on account of the downward movement of fungal spores in the sandy soil. Moreover, exchangeable calcium and magnesium contents are also high which might be responsible for the increase in the number. Quantitative data concerning soil microfungi of all plots are subject to considerable variation whether the plots are in the same area or are differently located. Previous workers have also shown that the number of fungi varies in different habitats (Jensen, 1931, Orpurt and Curtis 1957, Rose and Miller 1954, Saksena, 1955). Rose and Miller (1954) have established that the fungal counts from soil samples taken from the same field showed variations of the order of 1 : 13 (50,000–641,000) per gm. of soil.

GRAPH 1

[268]
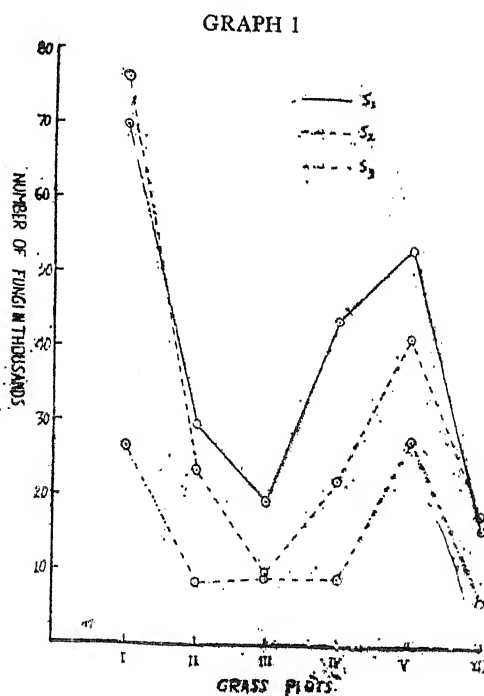
Moisture contents.—The effect of moisture contents upon the fungal flora has been emphasised by several workers. If the mosisture content of the soil is high, the decaying process by fungi will be quicker and their number will automatically increase. Grass plots I, II and III were studied in the summer season when the moisture content of the top horizon was not high. Grass plot III has the lowest percentage of moisture content (7%) in S¹ soil where the number of fungi per gm. of dry soil is the least (19,717). Survival of fungi in such soil is favoured by the development of the draught resistant capacity of spores possessing thick walls, production of ascocarps, sclerotia, chlamydospores etc. Most of the fungi isolated from the top horizon have draught withstanding capacities such as *Rhizopus*, *Mucor* sp. produce zygospores ; *Aspergillus niger* and other species of this group possess spiny thick wall on conidia ; *A. nidualans*, *A. variecolor*, *Neocosmospora* produce perithecia ; *Penicillium raistrickii* produces sclerotia ; *Myrothecium verrucaria* aud *Fusarium chlamydosporum* produce thick walled conidia and chlamydospores respectively. Moisture content in other plots vary.

GRAPH 2
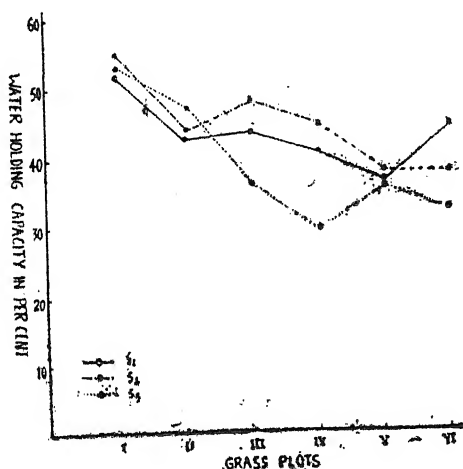
Water-holding capacity is variable in all the plots. Graph 2 shows its amount in different plots. Its value is the highest in the middle horizon of grass plot I which is in accord with the number of fungi per gm. of soil.

Soil reaction.—The pH of all the types of soil ranges between 6·6–8·6. The only grass plot with slightly acidic soil is V and the rest are either slightly alkaline or alkaline. Grass plot IV has the highest pH value (8·6). The number of fungi per gm. of soil in the most alkaline grass plot (IV) is somewhat lower than in the plot V which is slightly acidic but the variety of species in the former is not less than in the latter. Waksman (1927) also reported that fungi were abundantly found in the alkaline soils and played a good role in the microbial activity of such soils. Jensen (1931) pointed out that certain species were abundant in alkaline soils and others in acidic soils. Warcup (1951) distinguished two main groups of fungi : those occurring in acidic soils and those which preferred alkaline soils. Shetye (1956) found the number of fungi in the lime bed to be great but the variety was less. Whatever the case may be the high pH values in the soil encourage the bacterial population and their possible antagonistic effect may tell upon the fungal population while in acidic soils the bacterial growth is impeded and fungi can grow fairly.

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Organic matter.—Organic matter is one of the important constituents of the soil and is required for the growth of soil fungi. When it is decomposed, it provides soil with nutritive material and energy. The water-holding capacity is governed by the presence of organic matter. All the soils of plots, excepting a few, are provided with good proportion of organic matter (graph 3). From the data recorded in Table I and graph 3, it may be seen that there is some sort of correlation between the organic matter content of soils and the number of fungi per gm. of dry soil. The highest value was found in the middle horizon of the grass plot I and the lowest value was recorded in the same plot in the lowest horizon. The highest number of fungi in the middle horizon of the first plot (graph 1) may be attributed to the highest value of the organic matter. The large number and variety of fungi even in most alkaline soil of the plot IV may be attributed to the fair amount of the organic matter present there. Exception is seen with the plot VI. Though there is enough amount of organic matter (2·5%) in the top soil, the number of fungi per gm. of soil is lower than the other plots. It may be due to the fact that plot remains submerged under water and due to unaerobic condition growth of the fungal flora may not be favoured. Another exception is with the top horizons of plots II and III where organic matter is 0·93% and 2·9% (graph 3) respectively. The greater number of fungi in case of II than in the III may be explained if contents of nitrate, exchangeable magnesium, sodium and potassium are taken into consideration which are higher in case of plot II.

GRAPH 3
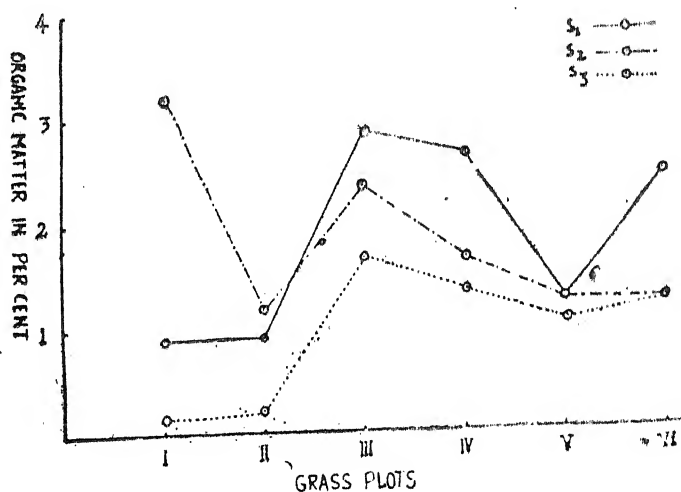
Exchangeable calcium and carbonate content.—Formation of pebbles and crumb structures due to calcium provides the soil with fair aeration to enhance the growth of microorganisms in soil. Another important role of calcium is to neutralize the acidity of soil created by putrefaction of organic matter. The high acidic soil may impede the growth of fungi which is thus controlled by presence of calcium. From the data given in Table I and graph 4, it is evident that all the soils of different grass plots are well supplied with exchangeable

calcium. Its content is not uniform in different depths. In plot V its value increases with depths while in others it is greater either in the middle or in the lowest horizons. There exists some relationship between the exchangeable calcium content and the fungi isolated. In the middle horizons of plots I and VI, the increase in the number of fungi per gm. of soil may be attributed to the presence of higher value of calcium also. In plot III though the number is less, the variety of species is large which may be due to it. The highest value in all the S^3 soils is in the plot V which is in accordance with the highest number of fungi in the same horizons.

Magnesium.—All the plots are supplied with exchangeable magnesium. The highest amount is present in plot I and the lowest in plot III at the top horizons which is in accord with the number of fungi isolated *e.g.* 70,000 and 19,717 per gm. of dry soil respectively. The top horizon of the plot V comes next in its magnesium content (0·213 m.e. %). The number of fungi is 54,500. The next higher value is 0·2 m.e. % in polt IV with 44, 418 fungi which is the next higher in the top horizons. The highest amount of magnesium in the lowest horizons is 0·206 m.e. % in the plots I and the lowest value is 0·173 m.e.% in the plot VI. The number of fungi per gm. of soil is also in accordance with it (26,666 and 6,245 respectively).

GRAPH 4
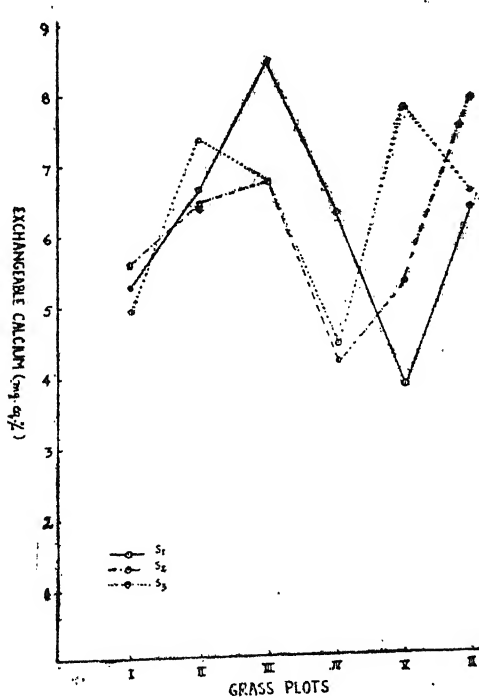
Exchangeable potassium and sodium.—Their utility in green plants and animals are of great value but the knowledge regarding its effect on fungi is scanty. Steinberg (1946) studied the quantitative relationship between the amount of

potassium in the medium and the weight of mycelium produced by *A. niger*. From the data in Table I it is seen that all the plots are supplied with exchangeable potassium and sodium. The lowest value is 2·6 m.e. % in the middle horizon of plot VI and the highest value is in the lowest horizon of the plot II. The highest value of sodium is in the most alkaline grass plot IV at the lowest horizon (16·4 m.e. %).

Nitrate, nitrogen and phosphate.—Nitrogen is used by fungi for functional and structural purposes. Robbins (1937) classified fungi into four groups according to their ability to utilize different sources of nitrogen such as atmospheric nitrogen, nitrate nitrogen, ammonium nitrogen and organic nitrogen. Some utilize the latter three types, some only ammonium nitrogen and organic nitrogen and still others utilize only organic nitrogen. Therefore it is difficult to correlate fungal population with the source of available nitrogen. From the data in Table I, it is evident that all the grass plot soils are well supplied with nitrate content. The highest and the lowest values recorded for the top horizons are in plots I and VI (12 mg. and 5·4 mg. in 100 gm. respectively) which correspond with the highest and the lowest figures for the number of fungi. In the same way the highest value in the middle horizons is in plot II (10·6 mg./100 gm. of soil) which is in accord with the total number of fungi per gm. of dry soil.

Phosphate is present in all the plots. Its highest value is present at the top horizon of the grass plot IV. The soil of the plot III at each horizon contains less amount of phosphate and it seems, therefore, that decrease in the total number of fungi in the top horizon of this plot may be due to this factor also.

Summing up the edaphic factors such as moisture content, water-holding capacity, organic matter, nitrate content, exchangeable calcium, magnesium and surface cover have greater influence on the fungal population in the soil. Though it becomes somewhat difficult to explain and correlate the certain observations depending upon a large number of factors yet the author has interpreted his findings with possible correlation existing among fungal population and various edaphic factors.

Summary

An ecological study of soil microfungi from six grass plots, supporting the growth of different dominant grass species and situated either in the same locality or in different sub-divisions of Varanasi district, was undertaken. The pH of soils varied from 6·6–8·6 and texture was Gangetic alluvium to sandy. Soil samples were collected from three different depths *viz.*, 0–6", 6"–12" and 12"–18" with aseptic precautions and were studied by dilution plate method on peptone-dextrose agar with rose bengal for the presence in them of fungi. Phytosociological study of surface cover was made and dominant and sub-dominant grasses were noted down. Determination of physico-chemical characters of soils such as pH, moisture content, water-holding capacity, organic matter, carbon content, carbonate content, available nitrogen, nitrate, phosphate, exchangeable calcium, potassium, sodium and magnesium were determined and phyto sociological analysis of fungi was done. Each Petri plate was treated as a unit of study analogous to a quadrat used for a similar study of higher plants. The number of fungi decreased downwards in the profile. Moisture content, water-holding capacity, organic matter, nitrate, phosphate, exchangeable calcium, magnesium and surface cover seemed to favour the appearance and growth of fungi in soil. pH had no apparent influence on them.

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THE FUNGAL MICROFLORA OF THE 'CUMIN WILT-SICK SOIL' AND THEIR ANTAGONISTIC EFFECT ON WILT CAUSING *FUSARIUM* IN VITRO

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Cumin (*Cuminum cyminum* L.) is extensively grown in North-Eastern Region of Rajasthan. This Region has a characteristic tropical climate. The soils are sandy loam to clayey, in general alkaline in nature. The wilt of cumin caused by *Fusarium oxysporum* f. *cumini* Prasad and Patel is wide spread in Ajmer Division and is responsible for considerable damage to the crop (Mathur and Prasad, 1964*a*). It is most destructive in Tonk, Ajmer, Jaipur and Bharatpur districts. •

In cultivated fields, the soil constitutes the zones of intense microbial activity around the root surfaces affecting the pathogenic and non-pathogenic micro-organisms. Studies on soil borne pathogens have shown that their distribution may be governed by host and other biotic factors (Waksman, 1944). The studies on soil microflora has also contributed much information on the activity of the microflora in different soils and have shown that relatively high proporiton of isolates from these flora are antagonistic to plant pathogens. The panama wilt disease of banana caused by *Fusarium oxysporum* f. *cubense* (E. F. Smith) Snyder and Hansen has received some attention, possibly because it is very difficult to control by more orthodex methods (Meredith, 1944). A similar work with wilt of pegion pea caused by *Fusarium udum* Butler was undertaken by Vasudeva and Roy (1950). A study of microflora of cumin wilt-sick soil of Rajasthan and prevalence of antagonistic fungi to *F. oxysporum* f. *cumini* was made.

Meterial and Methods

Soil samples were collected from wilt-sick fields in the month of March, just before harvesting of the crop from different places representing various soil textures in cumin growing area. Soil from 6 in. diameter around the wilted plants was collected in tins, after scraping the surface soil and isolations made as usual by soil dilution plate method on potato dextrose agar, Smith's medium, Waksman's medium and Czapek's medium. The soil texture and its pH are represented in Table I. To avoid loss of slow growing fungi which might be covered by fast growing types, all plates in series were checked frequently under a binocular microscope for a period of two weeks and the fungi were sub-cultured on potato dextrose agar to simplify the identification of those fungi.

For antagonistic studies, the test fungi and test organisms were simultaneously inoculated on the two edges of petri plates on potato dextrose agar and the plates were examined upto a fortnight for inhibition zones between two organisms represented as the distance between the margins of the colonies of two fungi along the middle of the petri plates.

TABLE I

Place of collection	Soil type	pH
Hindon	Sandy loam	8·4 to 8·7
Gangapur	Sandy loam	8·8 to 9·5
Bayana	Sandy loam	8·3
Bassi	Sandy loam	8·1
Deoli	Clay loam	8·2
Kekri	Clay loam	8·1 to 9·1

TABLE II
Fungi isolated from cumin wilt sick soils

Fungi isolated	Places of soil collection					
	Hindon	Gangapur	Bayana	Bassi	Deoli	Kekri
Alternaria tenuis Nees ex Pers	+		+	+		
Aspergillus sparsus Raper and Thom					+	+
A. candidus Link		+	+	+		
A. flavipes (Bain and Sart) Thom and Church						+
A. flavus Link					+	
A. funiculosus G. Smith			+	+		+
A. fumigatus Fresenius	+					
A. koningi Oudemans		+				+
A. nidulans (Eidam) Winter					+	
A. niger van Tieghem	+	+	+	+	+	+
A. sachari Chaudhuri			+	+		
A. sydowi (Bain and Sart) Thom and Church	+	+	+	+		
A. tamarii Kita	+					
A. unguis (Emile Weil and Gau) Thom and Rap			+			
A. versicolor (Vuill) Tiraboschi	+	+			+	+
A. wentii Wehmer	+		+			
Aspergillus sp. (Unidentified)	+	+	+	+	+	+
Botrytis sp.			+			
Cephalosporium sp.				+	+	
Cladosporium sp.	+	+	+			+
Curvularia geniculata (Tr. and Ear) Boed			+			

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Fungi isolated	Hindon	Gangapur	Bayana	Bassi	Deoli	Kekri
Curvularia lunata (Wakker) Boed			+			
Curvularia verruculosa Tandon and Bilgrami		+				
*Cyphollopycnis sp.		+				+
Epicoccum nigrum Link						+
Fusarium oxysporum Schl	+	+	+	+	+	+
Fusarium solani (Mart) App. et. Woll.			+	+		+
Fusarium sp. Link			+			
Fusarium semitectum Berk and Rav.						+
Humicola fuscoatra Traaln						+
Helminthosporium sativum Pammel, King and Bakke			+		+	+
*Leptosphaerulina australis McAlp						+
*Malustela aeria Batista, Lima and Vasc.		+	+			
Mucor sp.						+
Myrothecium roridum Tode ex Fr.		+			+	
Myrothecium striatisporum Preston	+					
**Neocosmospora ovatum Mathur	+					
**Neocosmospora ovatum var *giganteum* Mathur	+					
Neocosmospora vasinfecta Smith						+
**Neocosmospora vasinfecta var *crocea* Mathur		+				
Nigrospora oryzae (Berk and Br) Petch	+	+				
Nigrospora sphaerica (Sacc.) Mason	+		+	+		
*Nodulisporium africanum G. Smith						+
*Paecilomyces parsicinus Nicot						+
**Paecilomyces sp.	+					
**Paecilomyces sp.			+			
**Paecilomyces sp.				+	+	
**Paecilomyces sp.			+			+
*Pseudoplea australis McAlp.					+	+
Penicillium decumbens Thom			+		+	
Penicillium funiculosum Thom			+			
Penicillium javanicum Van Beyma	+		+			
Penicillium terrestre Jensen		+	+			
Penicillium sp.				+		

Fungi isolated	Hindon	Gangapur	Bayana	Bassi	Deoli	Kekri
Penicillium sp.		+				
Phoma sp.			+			
Phoma sp.					+	
Phoma sp.					+	
Pullularia pullulans (de Bary) Berkh				+	+	
Pythium sp.					+	+
Rhizoctonia solani Khun	+	+			+	+
Sclerotium sp.					+	
Sphaeronema sp.					+	
Stachybotrys atra Corda			+			
**Stachybotrys atra* var *microspora* Mathur and Sankhla	+				+	
Trichothecium roseum Link ex. Fr.	+	+	+	+	+	+

Note—+Denotes presence of the fungus.
*New reports from Indian Soil.
**New species.

Conclusion and Discussion

A list of fungi isolated from the wilt-sick soils is given in Table II. The soils of Bayana and Kekri were rich in fungal flora looking to the number of species of fungi isolated, and those of Deoli and Gangapur were poor. *Aspergillus* was found to be the most prevalent genus. Each type of soil had some species or the other of *Aspergillus*, though the species differed in their distribution. The most preponderant species were *Aspergillus niger* van Tieghem, *A. candidus* Link, *A. versicolor* (Vuill) Tiraboschi, *A. funiculosus* G. Smith. *Aspergillus niger* was found in all the types of soils studied. Some species of *Aspergillus* showed rather a restricted distribution. Only a few species of *Penicillium* were isolated. The occurrence of *Penicillia* in the soils studied was poor as compared to that of *Aspergilli*. Waksman (1944) pointed out that the species of *Penicillium* appear common in temperate soils, species of *Aspergillus* in tropical soils and the general run of pathogenic fungi occurs in quantity only where suitable hosts grow or where conditions favour their continued existance.

Other notable genera of Moniliales found to be of wide occurrence were *Paecilomyces* and *Curvularia*. Three new species of *Paecilomyces*, one new species and two new varieties of *Neocosmospora* and one new variety of *Stachybotrys atra* were isolated. Species of *Cladosporium* were common. Several fungi not reported from Indian soils have also been isolated. The soils under study seem to be rich in Ascomycetes and poor in Phycomycetes. Some fungi could not be identified being in mycelial forms only. No co-relation was visible in soil type and microflora. Waksman (1944) recorded that species of *Mucor, Penicillium*; *Trichoderma* and *Aspergillus* predominate in soil and are closely followed by species of *Rhizopus, Fusarium, Cephalosporium* and *Verticillium*. *Fusarium* are frequently

isolated but mostly represent saprophytic rather than parasitic forms. Colonies of *Sclerotium*, *Curvularia* and *Helminthosporium* may occasionally be found.

The cumin wilt *Fusarium* existed in varying cultural and morphological forms in soil, even one gram soil contained various type of isolates (Mathur and Prasad, 1964*b*). The pathogenic isolates as well as the soil isolates exhibited characters belonging to soil-inhabitants. Park (1958) concluded that the forms of *Fusarium oxysporum* causing vascular wilts of the palm is a soil inhibitory saprophyte and it seems more than probable that this conclusion will be extended in other forms of *Fusarium oxysporum* causing wilts.

The micro-organisms isolated from soils were tested in vitro to see whether they showed antibiosis against *Fusarium oxysporum* f. *cumini*. Only two isolates of *Aspergillus niger* inhibited growth of the *Fusarium* as shown in table III. Vasudeva and Roy (1950) isolated *Aspergillus niger* and *A. terreus* which secreted inhibitory substances in potato dextrose broth and inhibited *Fusarium udum* on solid media.

TABLE III

Antagonistic activity of Aspergillus niger *against* Fusarium oxysporum *f.* cumini *in culture*

Aspergillus niger isolates	Inhibition zones in mm
A. 28	17
A. 73	12

None of the isolate of *Fusarium oxysporum* inhibited the growth of either other fungi or that of isolates of *Fusarium oxysporum*. Buxton (1960) isolated a large number of micro-organisms including *Pythium* sp., *Penicillium* sp. and *Stachybotrys atra* showing antibiosis against *Fusarium oxysporum* f. *pisi*. He further reported that several isolates of *Fusarium oxysporum* not only occur in abundance in the rhizosphere, but can inhibit the pathogenic forms specialis of the same species, but different strains with in one species differ in their ability to inhibit pathogenic *Fusarium oxysporum*. None of the isolates of cumin wilt *Fusarium* from wilt-sick soil showed the above character.

Summary

A comparative study was made of microflora of cumin wilt-sick soil of Rajasthan. *Aspergillus niger*, *A. candidus*, *A. versicolor* and *A. funiculosus* were most preponderant. The soils were rich in Ascomycetes and poor in Phycomycetes. Two isolates of *Aspergillus niger* showed antagonistic properties against *Fusarium oxysporum* f. *cumini*.

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METABOLISM OF DETACHED LEAVES—I. CHANGES IN PROTEIN AND FREE AMINO ACIDS IN BETEL LEAVES, CULTURED IN DISTILLED WATER, IN LIGHT AND DARK

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[Received on 2nd November, 1964]

Introduction

Metabolism of detached leaves has been studied, among others, by Chibnall (1939), Vickery *et al* (1937), and Ranjan *et al* (1960). Degradation of protein level in detached leaves and the accumulation of free amino acids and amides at the expense of protein breakdown has been evident (Chibnal 1939 ; Vickery *et al*, 1937 ; and Ranjan *et al*, 1960).

Betel leaves are used raw with certain other ingredients by a large number of persons in India. It is customary that the leaves are kept detached from the plant under certain storage conditions with occasional weeding out of the rotten leaves. It is done to give the leaves a character of easy brittleness, better flavour and agreeable taste. The leaves also, in some cases, become whitish which to the casual observer is the right stage of "curing" which it has attained. The chemical changes leading to the widely prevalent practice of "curing to whiteness" has not been unsheathed. The present investigations throw some light on the nature of chemical changes undergone during this deliberate storage of betel leaves. Amino acid metabolism has been reported here and investigations pertaining to other metabolites will follow subsequently. Since protein-bound amino acids did not show any qualitative change during the culture-period, no data pertaining to them have been presented.

Materials and Methods

Betel vine (*Piper betle* var. *deshi kakair*) was used for experimentation. The seedling plants were raised from small stem cuttings, bearing few nodes of the previous year's crop, in manure-rich earthenware pots under green house conditions. The investigations were undertaken with plants grown to a uniform size bearing 10 leaves per plant.

Average sized leaves selected from a group of about 50 leaves, collected from the fourth node down from the apex, were washed in running tap water, blotted gently, and exposed to air current from a fan for 15 minutes to remove surface water.

Three randomly selected leaves, from the group of finally selected leaves, were analysed separately for amino acids and amides to check the uniformity of such a sample. Chromatographic analyses gave a uniform picture within this triplicate sample, leading thereby, to the assumption that the finally selected leaves were uniform not only in regard to their growth but also of close resemblance in their metabolic state. Combined extract of these leaves served as the initial sample for chromatographic analysis.

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The leaves (15 each, for light and dark), with their petioles dipped in distilled water (changed after every second day) in 100 ml. beakers, were placed in a dark chamber at room temperature (22°C±2°C) ; similar other set being exposed to diffused day-light during the day and to 200-W electric bulb kept at a distance of 30 cms. during the night. A stream of running water was introduced in a jacket between the light source and the leaf chamber to absorb the excess heat.

Extraction of protein and 80% ethanol soluble fractions, and chromatographic technique, were those followed by Ranjan *et al* (1960). Visual observation of spot intensity of amino acids was well in conformity with the area measurements with the help of a planimeter.

Results

Analysis of the protein of the betel leaf revealed the presence of leucines and phenylalanine, valine, proline, α -alanine, glutamic acid, aspartic acid, glycine and serine, and threonine. During culture period in both light and dark protein degradation was revealed by a general decrease of practically all protein amino acids.

Amino acid analysis of the alcohol soluble fraction immediately after detachment (1 hour after detachment ; initial sample) showed the presence of leucines and phenylalanine, valine, γ–aminobutyric acid, α–alanine, glutamic acid, aspartic acid, asparagine, threonine, glycine and serine, and lysine and histidine. The absence of proline and appearance of γ–aminobutyric acid in the alcohol soluble fraction was observed (Table I). The former was, however, present in the protein fraction.

TABLE I

Changes in free amino acids and amides in detached betel leaves cultured in light and dark

Amino acids	Initial sample	Hours after detachment and culture in light				Hours after detachment and culture in dark			
		48	96	144	192	48	96	144*	192
Leucines and Phenylalanine	4·8	–	–	–	–	–	–	5·8	6·5
Valine	0·8	–	–	–	–	–	–	1·9	2·4
γ–aminobutyric acid	0·3	0·8	1·8	2·9	3·3	–	–	1·5	2·3
Tyrosine	–	–	–	–	–	2·0	0·9	3·3	3·6
α–Alanine	2·3	1·8	1·9	2·8	3·0	3·6	3·4	7·1	8·0
Glutamic acid	3 4	5·0	5·4	5·5	4·6	5·5	7·1	7·2	8·2
Aspartic acid	3·3	5·2	4·7	5·2	4·5	5·0	4·5	5·8	7·3
Asparagine	2·1	1·8	2·3	3·3	3·8	3·0	3·5	6·1	9·2
Threonine	1·5	0·2	0·3	0·6	2·3	1·2	1·3	2·0	2·1
Glycine and serine	2·7	3·4	2·2	3·0	3·7	3·6	4·5	5·7	5·8
Lysine and histidine	–	0·3	–	–	–	–	–	3·8	2·9

Figures represent the area of amino acid spots in sq. cm.

*The leaves kept in the dark showed distinct signs of etiolation after 144 hours.

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Figure 1 portrays the behaviour of non-protein free amino acids and amides during excised leaf culture in light and dark. The amino acids appearing sparingly on the chromatogram are, however, not graphically represented. Although the general trend of response was the accumulation of practically all the free amino acids and amides with minor fluctuations nevertheles , initial starvation induced qualitative changes and it was at later stages of staivation that no such qualitative changes could be observed, when the free amino acids exhibited marked changes among themselves.
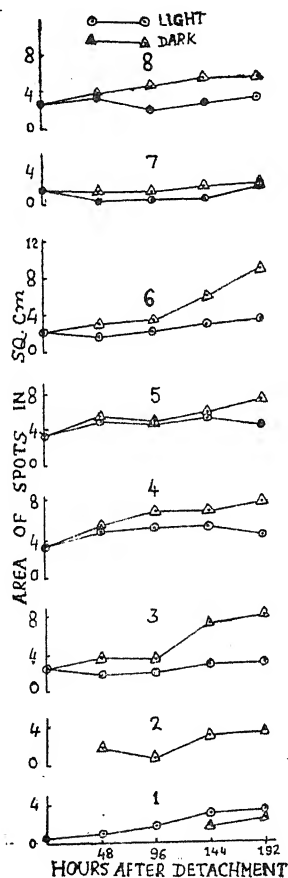
Fig 1. The behaviour of certain free amino acids and asparagine in detached betel leaves in light and dark.

1. γ—amino butyric acid ; 2. Tyrosine. 3. α—alanine ; 4. Glutamic acid ; 5. Aspartic acid ; 6. Asparagine ; 7. Theronine ; 8. Glycine and serine.

Of the two amides, asparagine and glutamine, the former which was the only one traceable accumulated considerably much more in the dark than in light as was usual with practically all the amino acids reported in table I. α alanine, glutamic acid, aspartic acid, asparagine and glycine + serine were visibly the dominant amino acids on the chromatogram, and could usually show a steadily increasing level.

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Discussion

The dynamic state of protein leads us to visualize the synthesis and break-down of this important constituent as a simultaneous process in detached leaves. The accumulation of free amino acids in excised leaf may thus be regarded as the resultant of two forces, degredation of protein dominating over the synthesis. Synthesis of protein in detached leaves has, however, been shown by exploratory studies of Racusen and Arnoff (1954) and of Chibnall and Wiltshire (1954).

Although it seems fairly well established that the accumulation of the free amino acids in detached starving leaves, cultured in light and dark, may be a resultant of protein breakdown and synthesis ; the former dominating, the possi-bility of the synthesis of amino acids from the C-residues obtained due to rapid glycolysis, and the ammonia produced by the oxidative deamination of amino acids concomitantly occurring in detached leaves, cannot be ignored. Such a possibility is clearly borne out by the findings of Rogers (1954) who, through his radioactive studies, has shown that uniformly labelled sucrose was initially trans-formed most rapidly by darkened leaves into alanine, glutamate and aspartate and subsequent moderate incorporations were detected into glycine, threonine, valine and methionine. Evidently the comparatively more dominance of glutamic acid, aspartic acid and alanine in darkened betel leaves lends support to the findings of Rogers (1954). It is also consistent well with the view that these amino acids arose from pyruvate ; excess of α-ketoglutarate and oxaloacetate being available possibly through rapid glycolysis of starch apart from that derived from protein breakdown.

The rapid increases of the dicarboxylic amino acids, glutamic acid and aspartic acid, in detached leaves in dark, may thus be visualized upon as resultant of initial protein breakdown and synthesis at the expense of depleting carbohydrates in starving leaves. This reaffirms the central position of these amino acids constituting important links between the carbohydrate and nitrogen metabolisms. Increases in the other amino acids were largely due to portein breakdown and possible interconversions within the wide range of amino acids. The appearance of γ-aminobutyric acid and amide asparagine, which did not constitute the protein moiety in the betel leaf could only be looked upon as resultant of interconversions as well as some secondary reactions following protein breakdown.

As carbohydrates were usually sufficient in the leaves in light, protein break-down was occurring, however, the free amino acids accumulated as much as in the dark, but the respective levels of glutamic acid and aspartic acid were always lower in light than in dark possibly due to their utilization in the synthesis of protein which proceeds simultaneously to the breakdown in excised leaves cultur-ed in light at a more rapid rate ; this lends support to the findings of Ranjan et al (1960). The high level of various other free amino acids upto late hours in light seems to be due to the sparing action of carbohydrates in relation to amino acids. Absence of proline in the soluble fraction may be visualized as the result of its rapid interconversion to other amino acids in the free amino acid pool imme-diately after its release from the protein moiety.

Summary

Changes in the protein and free amino acids have been studied in detached betel leaves cultured in distilled water in continuous light and dark using paper chromatographic methods. Evidence is presented that although the total amino nitrogen content increases both in light and dark in excised starving leaves, the behaviour of individual amino acids varies considerably. Evidently non protein amino acids and amides undergo interconversions among themselves. The level of asparagine and a majority of free amino acids was higher in darkened leaves than those cultured in light ; possibly due to more rapid protein breakdown in the absence of sufficient carbohydrates.

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UTILIZATION OF MONOSACCHARIDES BY SOME ANTHRACNOSE FUNGI*

By

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Monosaccharides play a vital role in the nutrition of pathogenic fungi. It has repeatedly been shown that usually these organisms convert complex carbohydrates into monosaccharides before utilization. Apart from occurring freely in various fruits these sugars are also present as component units of oligosaccharides (*e.g.* sucrose) and different polysaccharides like starch, xylans and arabans. Carbon nutrition of anthracnose fungi causing fruit-rot has been studied by some investigators including Thind and Sandhu (1956), Grewal (1957), Thind and Rawla (1958), Misra and Pandeya (1962), Mueller (1962) and Misra and Thakur (1965). But so far no detailed investigation on utilization of monosaccharides by these pathogens has been undertaken. In the present study the rate of assimilation of different monosaccharides by four anthracnose fungi has been ascertained by regular chromatographic analysis of the culture media. The growth attained by these organisms after three different periods of incubation was simultaneously measured for gaining a proper understanding of the comparative efficiency of these fungi in utilizing different monosaccharides.

Materials and Methods

Single-spore cultures of *Colletotrichum gloeosporioides* Penz., *Colletotrichum papayae* P. Henn., *Gloeosporium psidii* Delacr. and *Gloeosporium musarum* Cooke et Mass. isolated from diseased fruits of mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and banana (*Musa paradisiaca* L.) respectively, were employed. The basal medium consisted of KNO_3, 3·5 g ; KH_2PO_4, 1·75 g ; $MgSO_4$, $7H_2O$, 0·75 g ; and distilled water 1000 ml. To this medium each monosaccharide was added singly in such a quantity so as to furnish 4 g of carbon per litre. Eight monosaccharides, *viz.*, D–glucose, D–fructose, D–galactose, D–mannose, L–sorbose, L–rhamnose, D–xylose and L–arabinose, were used. In each case the initial pH of the medium was adjusted to 5·8 as it was found to be most suitable. 25 ml of the medium was apportioned in each of the 150 ml Pyrex Erlenmeyer flasks and autoclaved at 15 lbs pressure for 15 minutes. After inoculation with the respective organisms they were incubated at 25 ± 1°C. Every day 0·005 ml of the medium from each set of flasks was analysed by circular paper chromatographic technique employed by Ranjan *et al.* (1955). The running solvent was *n*-butanol-acetic acid-water (4 : 1 : 5 ; upper phase) and the spray reagent used was aniline-diphenylamine phosphate (5 vols. 4% aniline, 5 vols. 4% diphenylamine and 1 vol. orthophosphoric acid ; Buchan and Savage, 1952). After spraying, the bands of different sugars were developed by heating the chromatograms at 110°C for 90 seconds. At the end of each incubation period the mycelial mats were harvested on previously dried and weighed Whatman No. 42 filter papers and simultaneously the pH of the filtrate was determined. Incubation periods of 5, 10 and 15 days were used. The average dry weight of the mycelial mats was taken as the criterion for growth. In order to visualize the

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comparative efficiency of growth attained by these anthracnose fungi on different monosaccharides the method recommended by Cochrane (1958) was employed. Accordingly, in each case the growth attained on glucose by a particular organism was taken as 100 and from this the values for growth of other sugars were adjusted.   This value has been termed as Glucose Index of growth and has been calculated by the formula—

$$\frac{\text{dry wt. on a particular sugar} \times 100}{\text{dry wt. on glucose}}$$

All the experiments were conducted in triplicate sets.

Results

The results obtained have been summarized in Tables 1 and 2.

TABLE 1

Showing dry weight of mycelium, pH of the medium and persistence of sugar during the utilization of different monosaccharides by four anthracnose fungi

Sugar	Days of incubation	C. gloeosporioides			C. papayae			G. psidii			G. musarum		
		Dry wt. mg	pH	Sugar present Days	Dry wt. mg	pH	Sugar present Days	Dry wt. mg	pH	Sugar present Days	Dry wt. mg	pH	Sugar present Days
GLUCOSE				6			5			5			10
	5	42·0	6·1		40·8	6·6		50·4	6·3		11·3	5·9	
	10	98·9	7·1		89·5	7·0		100·3	6·9		54·0	6·6	
	15	82·0	7·5		78·5	7·6		90·6	7·4		70·2	6·9	
FRUCTOSE				9			6			5			14
	5	29·9	6·6		40·6	6·9		45·8	7·0		12·0	6·3	
	10	80·0	7·2		87·5	7·2		93·1	7·4		57·4	7·1	
	15	76·2	7·6		81·1	7·8		82·9	7·8		81·0	7·4	
GALACTOSE				15			10			8			15
	5	25·1	6·0		34·3	6·3		31·2	6·4		12·5	5·8	
	10	82·5	6·7		84·3	7·1		95·3	6·9		30·4	6·1	
	15	91·5	7·0		84·7	7·2		89·1	7·0		42·3	6·4	
MANNOSE				7			5			8			13
	5	48·0	6·6		38·9	6·8		50·2	6·2		22·0	6·5	
	10	74·4	7·4		68·9	7·3		76·7	7·2		66·1	6·9	
	15	62·5	8·1		61·3	7·8		70·7	7·6		82·6	7·2	
SORBOSE				10			15			11			15
	5	9·6	5·8		8·3	5·8		19·7	5·9		3·8	5·8	
	10	57·1	6·7		35·7	6·1		77·3	6·7		17·1	5·9	
	15	62·7	7·2		75·1	6·7		82·7	7·0		28·1	6·3	
RHAMNOSE				8			8			8			15
	5	26·5	5·9		24·0	5·8		28·7	5·4		7·5	5·7	
	10	49·9	7·0		50·7	7·1		48·9	5·6		19·8	5·8	
	15	51·5	7·3		50·3	7·6		44·1	7·5		34·1	5·9	
XYLOSE				8			12			8			9
	5	21·9	6·1		14·9	6·1		32·2	6·3		20·8	6·1	
	10	83·3	7·0		64·3	6·7		78·5	6·7		79·1	7·0	
	15	81·3	7·2		72·5	7·0		67·3	7·0		68·9	7·2	
ARABINOSE				12			9			7			15
	5	13·7	6·1		26·7	6·2		39·4	6·6		17·6	5·9	
	10	70·3	6·9		73·7	7·1		89·3	7·1		42·0	6·7	
	15	74·8	7·3		73·7	7·3		79·8	7·4		64·7	6·9	

TABLE 2

Showing the Glucose Index of growth of four anthracnose fungi on different monosaccharides

Sugar	Days of incubation	C. gloeo-sporioides	C. papayae	G. psidii	G. musarum
FRUCTOSE					
	5	71	99	91	106
	10	81	98	92	106
	15	93	103	91	115
GALACTOSE					
	5	60	84	62	110
	10	83	94	94	56
	15	112	108	98	60
MANNOSE					
	5	114	95	99	195
	10	75	77	76	122
	15	76	78	78	117
SORBOSE					
	5	23	20	39	29
	10	58	40	77	32
	15	76	95	92	40
RHAMNOSE					
	5	63	59	57	66
	10	50	57	48	37
	15	63	64	49	48
XYLOSE					
	5	52	37	64	184
	10	84	72	78	146
	15	99	92	74	98
ARABINOSE					
	5	33	65	78	156
	10	71	83	88	78
	15	91	94	88	92

Discussion and Conclusions

It is evident from the results that all the monosaccharides employed in the present study were readily utilized by the four anthracnose fungi. Their rates of utilization as well as the amount of growth produced on them, however, showed much variation. Glucose, fructose, mannose and rhamnose were consumed at a rapid rate by all the organisms except *G. musarum*. Sorbose was assimilated at a slow rate. *G. musarum* consumed up xylose in a comparatively short period (9 days). The four anthracnose fungi showed marked differences

in their rates of utilization of galactose. *C. gloeosporioides* and *G. musarum* could not completely utilize this sugar within 15 days, whereas *C. papayae* and *G. psidii* took 10 and 8 days respectively to consume it.

Glucose and fructose supported good growth of all the organisms included in the present investigation. The maximum dry weight of all the pathogens, except *G. musarum*, on these sugars was obtained after 10 days of incubation and a decline was observed after 15 days. In case of *G. musarum* the highest dry weight on xylose was attained after 10 days of incubation and a decrease was noticed after 15 days ; on the rest of the sugars the dry weight recorded an increase upto the end of the final incubation period. In general, whenever a sugar was exhausted within a short period the dry weight at the end of the experiment showed a decline or tended to become constant.

All these four anthracnose fungi exhibited exceedingly poor growth on sorbose at the initial stage of incubation. Poor utilization of sorbose by fungi has been reported by numerous investigators. Lilly and Barnett (1953) have ascribed this phenomenon to the killing of the growing hyphal tips followed by branching of mycelium below the killed portion resulting in restricted colonial growth. At later stages the growth of the organisms under the present investigation showed much improvement on sorbose. This was apparently due to adaptation of these pathogens to utilize sorbose on prolonged incubation. Thind and Rawla (1958) reported slightly better growth of *Gloeosporium psidii* on sorbose than on glucose. The present isolate of *G. psidii* behaved differently, because at all stages of incubation the dry weight on glucose was more than that on sorbose. The isolate of *Gloeosporium musarum* studied by Grewal (1957) attained very good growth on L–arabinose. The growth recorded for the present isolate of *G. musarum* on L–arabinose was throughout less than that on glucose. *G. psidii* made comparatively poor growth on xylose. Similar observation was also made by Thind and Rawla (1958).

The results obtained in the present investigation indicate that the rate of utilization of monosaccharides could not always be correlated with the amount of mycelial output. Sometimes final growth attained by a particular organism on a sugar with a slow rate of assimilation was better than on a sugar with a rapid rate of assimilation.

The drift in pH of the medium showed similarity in all cases, differing only in minor details. The general trend showed a drift towards neutrality or slightly towards the alkaline side. It will be worthwhile to point out that the pH of the medium did not shift beyond the range found to be suitable for active growth of the present organisms in earlier observations.

The present results clearly show that the amount of the growth produced by a certain organism varied considerably on various monosaccharides at different stages of incubation. A sugar which supported poor mycelial development at early stage ot incubation often showed good growth at later stages. For example, when the growth of *C. gloeosporioides* on galactose is compared with that on glucose after 5 days of incubation, it would appear that the growth on galactose was much inferior. On the contrary, fromt he results of 15 days of incubation galactose would appear to be even better source than glucose. Obviously, this is due to the fact that on glucose there was a fall in mycelial dry weight at later stage of incubation, whereas the dry weight kept on increasing on galactose. Just the reverse case was observed during the utilization of mannose by *C. gloeosporioides*, where in spite of very good mycelial production at early stages of incubation the final attainment was comparatively poor. This elucidates the

drawback of the conventional practice of employing a single incubation period for harvesting the mycelial mats and assessments made from such data. It, therefore, seems desirable to employ a number of incubation periods and at the same time to find out the rate of assimilation of various sugars, in order to make a proper evaluation of the role of different sugars in the nutrition of fungi.

Summary

Utilization of eight monosaccharides, *viz.*, D-glucose, D-fructose, D-galactose, D-mannose, L-sorbose, L-rhamnose, D-xylose and L-arabinose, by *Colletotrichum gloeosporioides*, *C. papayae*, *Gloeosporium psidii* and *G. musarum* isolated from diseased fruits of mango, papaya, guava and banana respectively, was studied. Chromatographic analysis of the culture medium revealed that glucose, fructose, mannose and rhamnose were rapidly assimilated by all the organisms, except *G. musarum*. Sorbose was utilized at a slow rate. Mycelial output was good on glucose and fructose. The growth on sorbose was very poor at early stage of incubation, but at later stage much improvement was observed. The four anthracnose fungi showed much variation in their utilization of xylose and arabinose. In most of the cases where the sugar was exhausted from the medium within short period, a decline in the dry weight was recorded at later stage of incubation. The pH changes of the media showed a drift towards neutrality or slight alkalinity in all cases.

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ALTERNARIA LEAF SPOT OF TOMATO

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The importance of tomato as a vegetable crop has greatly increased during the last few years. It is not only used as a fresh vegetable, but is also canned alone or combined with other foods. It is an excellent source of vitamin C and can furnish other vitamins. Prevention of losses from diseases is a major factor in obtaining the maximum production of tomatoes. The losses can be avoided only when the diseases responsible for them are properly studied and effectively combated.

Alternaria leaf spot is one of the most common diseases of many wild and cultivated plants, including tomato. Many species of this genus, *viz.*, *A. longipes* (Ell. and Ev.) Mason, *A. solani* (Ell. and Mart.) Jones and Grout, *A. tomato* Cke., and *A. violae* Galloway and Dorsett (and some unidentified species) have been reported on Solanaceous plants in this country. Rangaswami and Sambandam (1961) reported occurrence of a new species of *Alternaria*, *A. melongenae* Rang. and Samb. on brinjal (egg plant) and chilli.

Butler (1918) considered *Macrosporium tomato* as a synonym of *A. solani* but both of them are now regarded to be identical with *A. tenuis* which may cause fruit rot of tomatoes in India. McColloch (1951) and Butler (1909) have reported a fruit rot of tomato caused by *A. tenuis* at Maryland and California respectively. Rangaswami and Sambandam (1961) isolated *A. tenuis* from diseased leaves of *Datura fastuso*, *Capsicum annum* and *Petunia hybrida*. They made a detailed study of its pathogenecity, host range and morphological, cultural and physiological properties. Kapoor and Hingorani (1958) mentioned that *A. tenuis* caused a leaf spot disease of brinjal, tomato and potato growing in the botanical area of Indian Agricultural Research Institute, New Delhi. They confined their investigations to brinjal only and in order to devise control measures they studied the mode of transmission of the disease.

Pathological studies on *Alternaria tenuis* Auct. causing leaf spot disease of tomato were undertaken because of the lack of proper information about this disease.

Materials and Methods

The fungus was isolated from the infected leaves of tomato collected from several fields at Allahabad and neighbouring places. The usual technique of isolation, purification and subculturing was used.

Artificial inoculations of *A. tenuis* were tried on different parts of the host. Pathogenecity tests were conducted on injured as well as uninjured surfaces. The surfaces were sterilized with 90% alcohol or 0·1% mercuric chloride. The leaf

surfaces were then thoroughly washed with sterilized water. Injury was always inflicted with the help of sterilized needle. Care was taken to avoid deep wounds. Reisolations were always made to confirm the results. The following methods of inoculations were tried :

(1) *Mass inoculation method.*—In this method a mass of spores and mycelium were placed on the injured or uninjured surface.

(2) *Spore suspension method.*—Spore suspension in sterilized water was prepared and it was sprayed with an atomizer on the injured or uninjured surfaces of the leaves.

Cross inoculations were carried out on different hosts. Various fungicides were evaluated in the Laboratory and the suitable ones were then sprayed or dusted on the leaves of the host at various intervals (both before and after artificial inoculations).

Symptoms

Plants in any phase of development may become infected by the fungus, but in fields the symptoms of blight disease appear first on older leaves which show round spots of light brown colour. They vary from 3 to 10 m.m. in diameter. Sometimes two or more spots coalesce together and give an irregular appearance. Due to the production of spores the colour of the spot gradually changes from light brown to dark brown. As the spots enlarge to 9 or 10 m.m. in diameter, they are readily recognised by the concentric rings or zonations and hence the name target spot has been used by some investigators, while referring to this disease.

Frequently the spots have also been observed to begin from the margins of the leaves which become curled or twisted. At that stage their symmetric ring like appearance is often lost in the uneven outline at the edge of the leaf. The diseased and healthy portions of the leaf are always separated by the warm buff colour. Lesions are confined only to the leaf blades. No lesions have ever been found on fruits of any age.

The disease of tomato by *A. tenuis* makes its first appearance by about the last week of September or the beginning of October. Infection is at its peak from the middle of December to early January. Fresh infection ceases at later stages when the temperature begins to rise and the humidity decreases.

Morphology of the Fungus and Host-Parasite Relationship

Only leaves of *Lycopersicum esculentum*, were infected by *A. tenuis*. The causal organism is generally incapable of producing any active rot on healthy mature fruits. Microtomed sections passing though the healty and diseased areas of the leaf and pathogenecity tests have established that the germ tube of *A. tenuis* was incapable of penetrating through the stomata or cuticle. Mycelium was always observed entering into the host tissue through injured surfaces (*viz.*, ruptured cuticle or epidermis).

Mycelium was intercellular and it consisted of light brown or dark olive buff hyphae which were septate and 3–7μ wide. Conidiophores were also septate, 38·7–75·4μ long and 2·8–5·6μ wide. They appeared in clusters from the dead spots. Conidia were very variable in shape and were formed in chains. Mostly they were very long, bottle shaped, terminating in a long septate cell and sometimes branched beak. They measured from 18·9–32·4 × 8·1–16·2μ and were divided by 2–6 transverse septae. Occasionally the broader compartments were further divided by 1–3 longitudinal septa. The spores were orange citrine in colour.

Text Fig. 1. Showing some infected leaves of Tomato

Text Fig. 2. Microphotograph of T. S. of tomato leaf showing intercellular mycelium.

Pathogenecity Experiments

In order to test the pathogenecity of *A. tenuis*, the organism was mass inoculated and/or was inoculated by spore suspensions on young as well as old leaves of tomato. It was observed that *A. tenuis* was able to cause infection only when the surface of the leaf was injured. It was incapable of infecting leaves without injury even though numerous stomata were present. Infection was possible by both methods, but the percentage of disease was comparatively greater when the inoculations were made by the 'mass inoculation' method.

Artificial inoculations by various methods established that the symptoms of the disease appeared between 3rd–5th day on old leaves and 5th–6th day on young leaves. Besides leaves the organism was inoculated on petioles, stems (young 20–30 days, old 4–5 months) and calyx of the flower. Apart from this the spore suspension was also sprayed through an atomizer on the young flower buds but no infection was observed in any case. Possibility of infection through hydathodes, which are present in the tomato leaf, was also ruled out as no infection took place when the inoculum was placed in their vicinity. It has been reported by various workers that susceptibility of tomatoes to decay by *Alternaria* is increased if tomato fruits are held for a week or more at low but not at freezing temperatures. In order to see whether the present species of *Alternaria* is capable of causing any rot of detached tomato fruits, ripe as well as green fruits were taken. They were kept at various temperatures (*viz.*, 5°C, 10°C, 15°C, 20°C and 25°C) for 7 days. Subsequently they were taken out and washed with 90% alcohol and inoculated by inserting a small mat of mycelium along with spores through a wound caused by a sterile scalpel. They were incubated at room temperature (25°C). After a week of incubation, they were examined and it was found that the pathogen did not grow in the surrounding tissue and it failed to develop any diseased lesions. These results demonstrated that *A. tenuis* was incapable of causing any rot to ripe or green fruits.

Fruits attached to plants were also inoculated with this fungus, but they also failed to get infected.

Cross Inoculation.—In order to determine the host range of the fungus, some of the important vegetable crops of the locality and certain other hosts which are susceptible to *A. tenuis* were inoculated with the present organism. The plants were examined after 10 days and the results are recorded in table 1.

TABLE 1

Showing the results of cross inoculations of different parts of various plants.

Name of the plants	Parts of the plant	Condition of the parts	
		Injured	Uninjured
Pandanus odoratissimus L.	Leaf	+	–
Areca alba, Bory,	Leaf	–	–
Ricinus communis L.	Leaf	–	–
	Petiole	–	–
Tagetes signata, Bartl.	Leaf	–	–
Dracaena fragrans, Ker-Gawl.	Leaf	+	–

Name of the plants	Parts of the plant	Condition of the parts	
		Injured	Uninjured
Acalypha indica L.	Leaf	–	–
	Petiole	–	–
Pyrus malus L. (Var. Golden delicious)	Datached fruits	+	–
Pyrus malus L. (Var. Ambri Kashmiri)	Datached fruits	+	–
Pyrus communis L. (Nakh)	Detached fruits	+	–
Solanum melongena L.	Leaf	–	–
	Datached fruits	–	–
	Attached fruits	–	–
Euphorbia pulcherrima, Willd. ex. Poir	Leaf	–	–
	Stem	–	–
Solanum tuberosum L.	Leaf	–	–
	Potato tubers	–	–
Capsicum annuum L.	Leaf	–	–
	Stem	–	–
	Attached fruits	–	–
	Detached fruits	–	–
Raphanus sativus L.	Roots	–	–
Gossypium arboreum L.	Leaf	–	–

(+ indicates infection while failure is represented by –)

The above results show that besides tomato *A. tenuis* could infect leaves of certain other plants also, provided the inoculum was kept on injured surface.

No infection was developed on stems and petioles of any plants inoculated with this organism. It was also able to cause infection on detached fruits of apples (two varieties) and pear.

Control Measures

Tillex (ethyl mercury chloride), diathane Z78, zinc ethylenebis (dithiocarbamate), copper sandoz (copper oxychloride), cuprovit (copper oxychloride), zinc sulphate, onyxide (mixture of alkenyl dimethyl ethyl ammonium bromides), isothan Q-15 (lauryl iso quinolinium bromide), spergon (tetrachlorobenzoquinone), zerlate (zinc dimethyl dithiocarbamate), ceresan (ethyl thiomercuric chloride), kirti₁ copper (copper oxychloride), bordeaux mixture (5 : 5 : 50) and peronox (copper oxychloride), were evaluated in the laboratory, so as to observe the inhibiting effect of these fungicides on the growth of the organism.

For this purpose, sterile pieces of cotton threads (1–2 inches in length) were sprayed on petridishes containing the medium. The fungus was inoculated in 9 to 10 petridishes and was allowed to grow over the threads. The pieces of threads were removed from petridishes with the help of sterile forcep and they

were cut into small pieces with sterile scissor. These cut pieces were either rolled or were dipped in liquid fungicides. These were then transferred to petridishes containing the medium which were subsequently incubated at 30°C. They were examined after five days. It was found that tillex, onyxide, isothan Q-15, zerlate, cerasan, kirti copper, spergon and peronox completely inhibited the growth of the organism. The minimum effective concentration of the effective fungicides were also determined in the same way as mentioned above.

For the field trials only tillex, peronox, onyxide, isothan and kirti copper were used. The fungicides were sprayed or dusted on the leaves at various intervals (both before and after artificial inoculations). The minimum effective concentrations determined on the basis of laboratory trials were used. The results are summarized in table 2.

TABLE 2

Showing the effect of A. tenuis *on the leaves of tomato* (Lycopersicum esculentum) *sprayed or dusted with various fungicides* (Sign + *or* − *has been used to denote the appearance or absence of disease respectively*).

	Time of inoculation	0·2% tillex	0·33% peronox	0·8% onyxide	0·8% isothan	50% kirti copper
1.	Just after application	−	−	−	−	+
2.	24 hours after application	−	−	+	+	+
3.	48 hours after application	−	−	+	+	+
4.	96 hours after application	+	+	+	+	+
5.	1 week after application	+	+	+	+	+
6.	Just before application	−	−	−	−	+
7.	24 hours before application	−	−	−	−	+
8.	48 hours before application	−	−	+	+	+
9.	96 hours before application	+	+	+	+	+
10.	1 week before application	+	+	+	+	+

Table 2 shows that 0·2% tillex and 0·33% peronox were more effective fungicides as compared to onyxide and isothan because they could check the spread of the disease provided they were applied 48 hours before or after inoculations.

Onyxide and isothan were effective, provided the inoculum did not fall on the host earlier than 24 hours. Kirti copper which was effective in the laboratory, was found to be useless when applied in the field. It could not check the disease at all.

Discussion

The present organism is a weak parasite as it can infect the plant through injured surface only. Similar results were also obtained by Tandon and Ghosh (1962) for *A. tenuis* infecting *Pyrus communis* (Nakh) fruits.

The infection was more easily achieved on older leaves and it appeared in shorter period than on younger ones. This appears to be due to greater suscep- tibility of older leaves.

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Cross inoculations on other plants showed that it could infect some other hosts. It is thus clear that the organism under study is not highly specific.

Chaturvedi (1961) established that the fungus could tolerate fairly high temperature and was able to survive on the host or in the soil for a very long time. These results indicate the reason for annual recurrence of the disease.

It has been established that 0·2% tillex and 0·33% peronox were fairly effective fungicides for the control of the leaf spot disease of tomato. The present investigations indicate that the effective fungicides could control the disease only if they could be applied within 48 hours of the association of the fungus with the host. Whenever the fungicides were applied earlier, the disease was not controlled. It will be very difficult to know the exact time when the fungus will reach the host and thus repeated application will be needed for effective control.

Summary

A detailed study of *Alternaria tenuis* Auct. causing leaf spot disease of tomato was made. The organism was brought in culture, purified and its pathogenecity was established. Cross inoculations were made and it was found that it could infect the leaves of *Pandanus odoratissimus* and *Dracaena fragrans* as well as the fruits of pears and two varieties of apples.

It was found to be a weak parasite and could infect the host only through injured surface. Laboratory evaluation of fungicides showed that tillex, onyxide, isothan Q-15, zerlate, cerasan, kirti copper, spergon and peronox could inhibit the growth of the organism. The disease could be controlled by repeated applications of 0·2% tillex and 0·33% peronox. None of the other fungicides were effective under field conditions.

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THE MUSCULATURE OF THE HEAD OF ADULT MYRMELEON (NEUROPTERA, MYRMELEONIDAE)

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Introduction

A. comparative study of a larva and its adult envisages to serve a two fold purpose : *firstly* it presents specefic characters of morphological and anatomical importance and *secondly* it renders valuable information regarding their structural differences of phylogenetic significance. These differences are liable to reflect changes in the musculature of the larva and its adult. Comparative studies of the musculature of larva and its adult have been hardly attempted so far. The only notable contribution is by Crampton (1921) who compared the muscles of the maxilla of *Corydalus* larva with that of its adult. Thus there is a great lacuna in such type of studies of comparative musculature. No doubt the contributions of Lozenski (1908), Miller (1933), Das (1937), Korn (1943), Kramer, (1955) and Ryuichi (1956) are of great importance in this reference but they restricted their studies either on the musculature of the adults or on the larvae of Neuropterous insects.

The present paper constitutes part two of the current study on the cephalic musculature of *Myrmeleon* larva (Srivastava, 1964) and its adult. It deals in detail with the cephalic muscles of the adult *Myrmeleon* ; the muscles have been compared with those of its larva. The existence of the remarkable difference in the feeding habits of the larva and that of its adult, namely piercing type of the former and chewing type in the latter, provides an interesting situation in their working mechanisms particularly with reference to the muscles associated with the mouth parts. The present work discusses the structure-function relationship in the light of the aforesaid statement.

Material and Method

Adult insects were collected by light traps in the urban locality of Adarsh Nagar, Ajmer. The insects were killed and preserved either in a solution of chloral hydrate and phenol (50 : 50) or in 70% alcohol. Dissections were done under a stereioscopic binocular microscope in 70% alcohol.

Head

The head (figs. 1 and 2) is large and compressed cephalocaudally. The mouth parts are of hypognathus type. The compound eyes are dark brown with a tinge of phosphorescent greenish blue shade. The head capsule is so strongly sclerotised and its regions so firmly fused that only a few sutures are visibly present. The coronal suture of the epicranial ecdysial cleavage line is present ; there are no frontal arms. Due to the absence of the latter the extents of frons are not clearly marked off. An epistomal suture separates the frons from the clypeus. The clypeus is roughly divided into two parts, the anteclypeus and the post-clypeus. The labrum is articulated with the anteclypeus. Lying laterad to clypeus and frons are the genae. The antenna is situated on a projection of the genal area.

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TB

PA   PA

DA   DA

AA

E   CS   E

A   A

G   ES   ES   G

FR

PC

AC

LR

M   M

OC

FM POS

PT

E HS E

PMT

CA AB

LG

34 33
35
E E

3 4 4
5 3
2

1 LR

7 — 13

CD 8

ST 9

12 10

15 14

16 LC

17 GL 11

18

MXP 19

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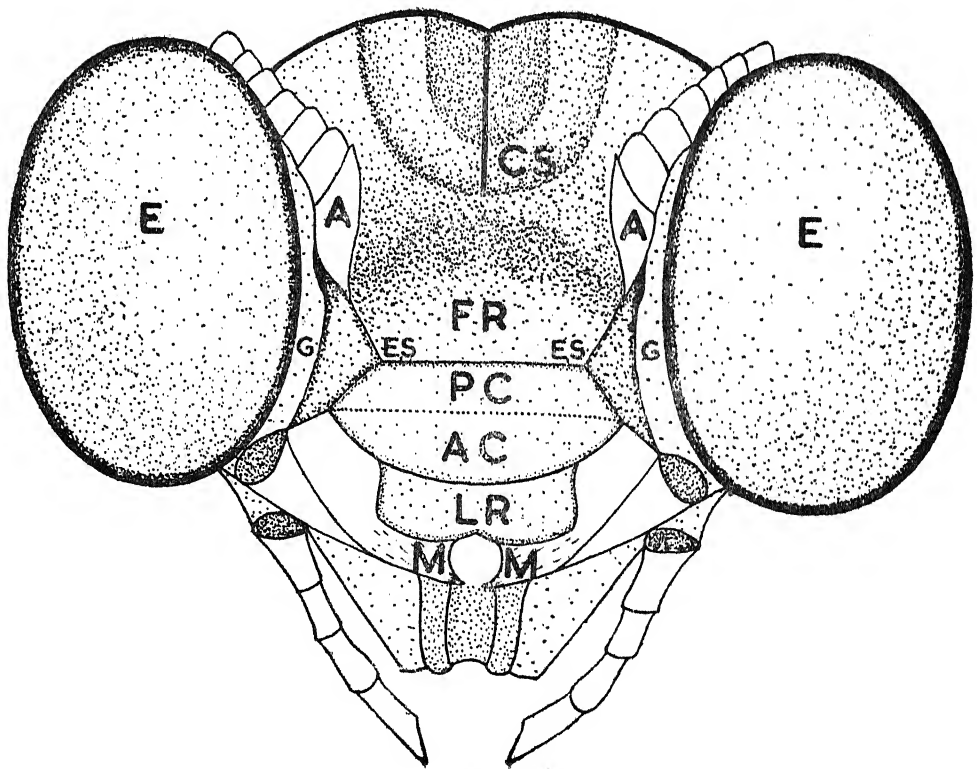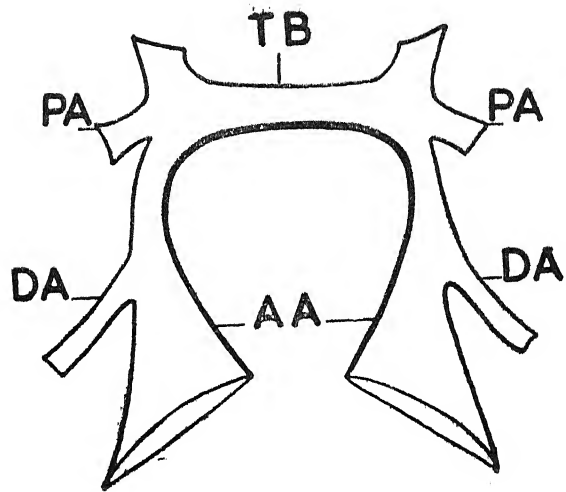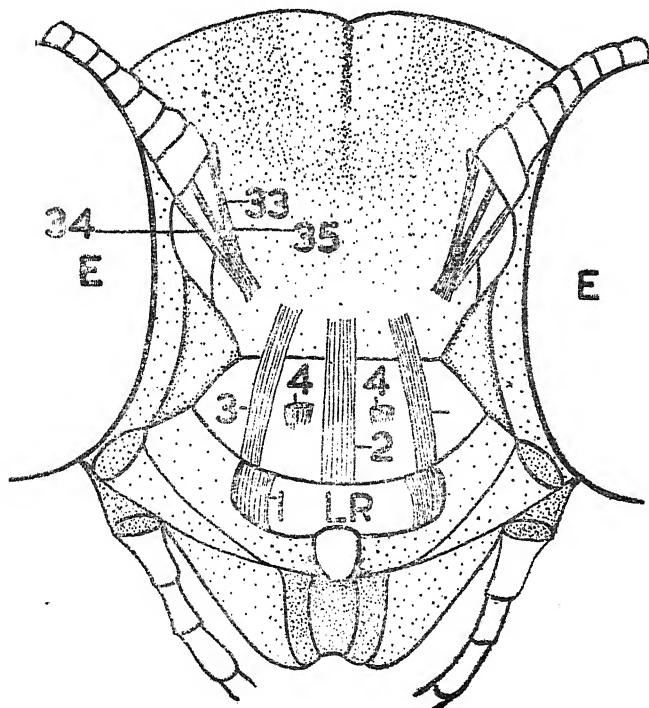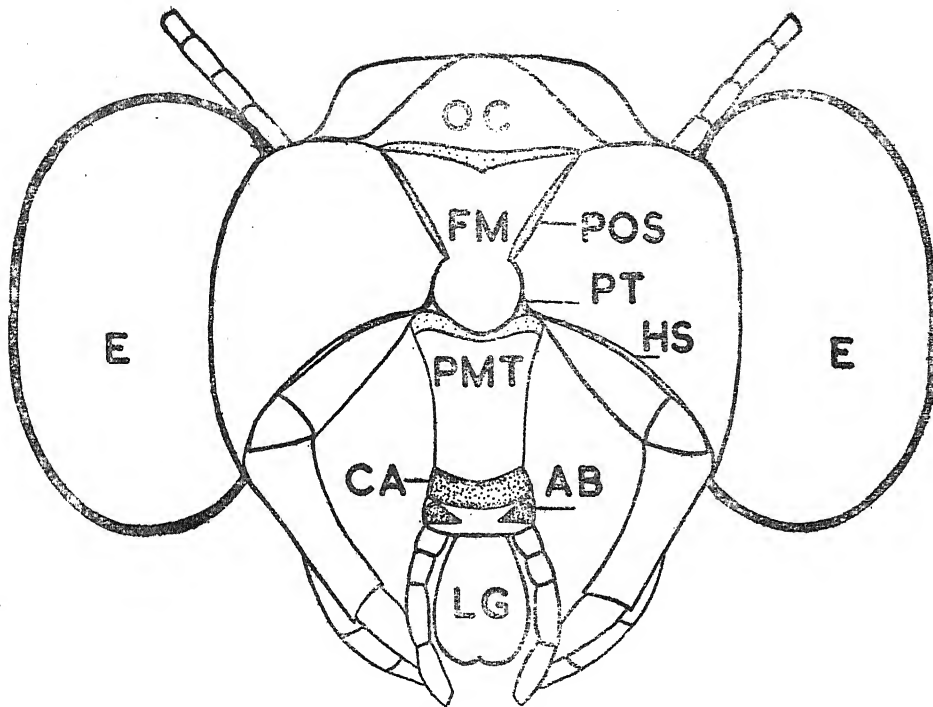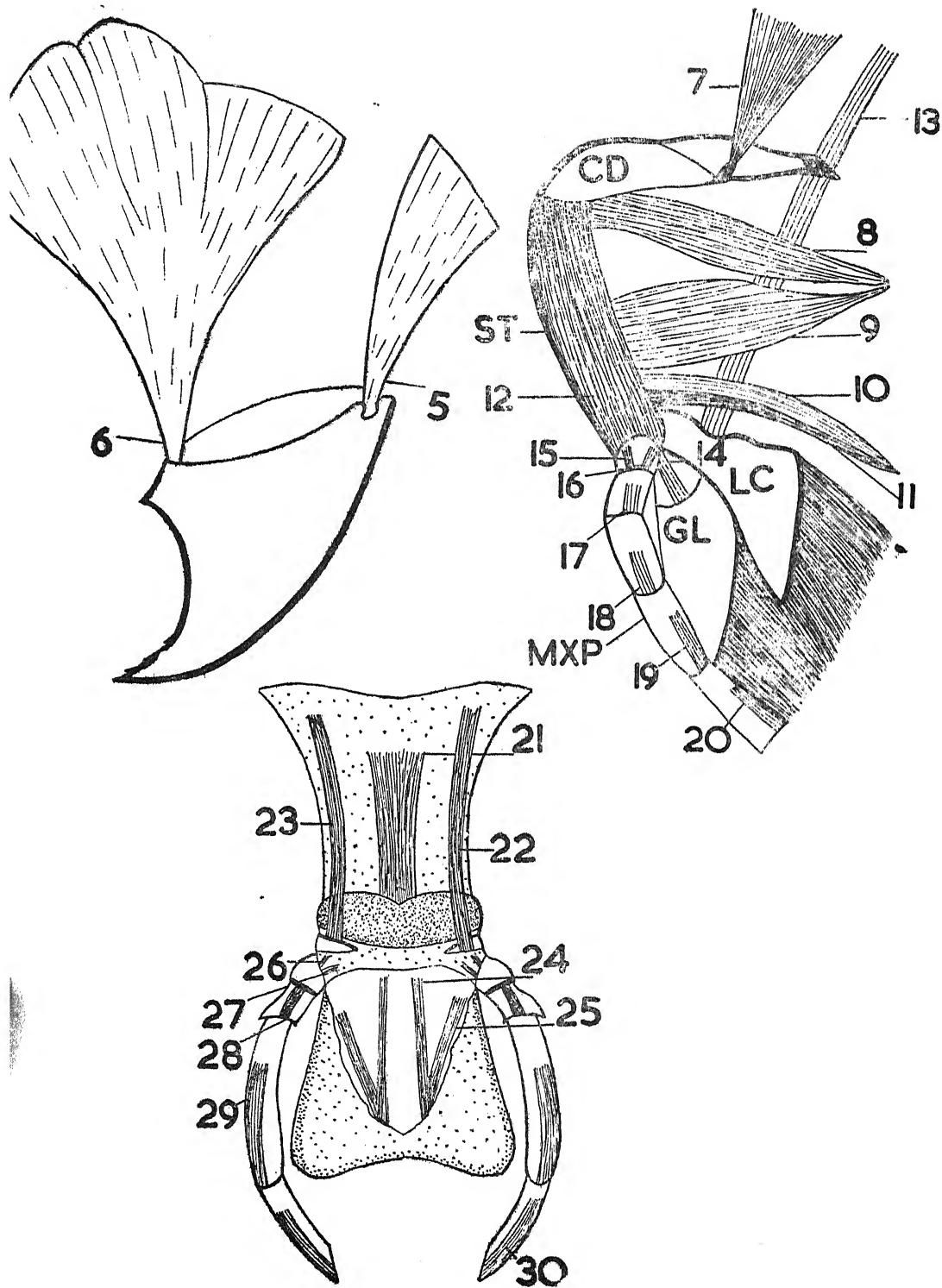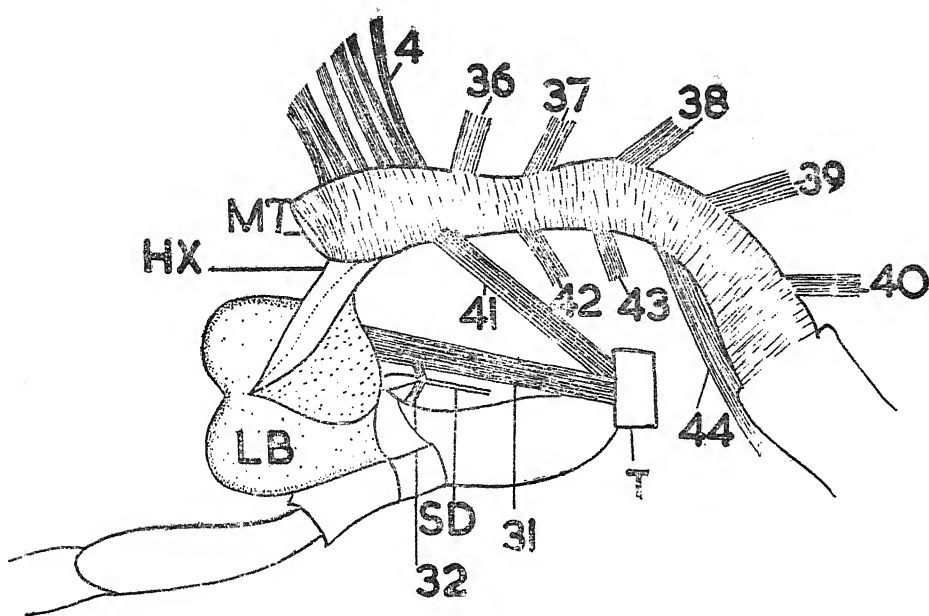
ABBREVIATIONS

A—antenna ; AA—anterior arm ; AB—anterior sclerite ; AC—anteclypeus ; CA—proximal sclerite : CB—anterior sclerite ; CD—cardo ; CS—coronal suture ; DA—Dorsal arm ; E—compound eyes : ES—epistomal suture ; FM—foramen magnum ; FR—frons ; G—gena ; GL—galea ; HS—hypostomal suture ; HX—hyphopharynx ; LB—labium ; LC—lacinia ; LG—ligula ; LP—labial palp ; LR—labrum ; M—mandible ; MXP—maxillary palp ; MT—mouth ; OC—occiput ; PA—posterior arm ; PC—post clypeus : PMT—post mentum ; POS—postoccipital suture ; Pt—posterior tentorial pit ; SD—salivary duct ; ST—stipes ; T—tentorium ; TB—tentorial bridge ; 1—compressor muscle ; 2—median labral ; 3—la ern l laberal ; 4—cibarial ; 5—lateral mandibular extensor ; 6—mesal mandibular extensor ; 7 —promotor of veracardo ; 8—adductor of cardo ; 9—adductor of stipes ; 10—cephalic stipital tentorial ; 11—caudal stipital tentorial 12—stipito-lacinal ; 13—cranial flexor ; 14—galeostipital muscle : 15-20—palpal muscles ; 21—retractor muscle ; 22—dorsal longitudinal retractor ; 23—ventral longitudinal retractor ; 24 and 25— fllexors of glossa and paraglossa ; 26-30—muscles of labial palpus ; 31—hypopharyngeal re-tractor ; 32—muscles of salivos ; 33—dorsal antennal ; 34—lateral antennal ; 35—mesal anten nal ; 36-40 dorsal pharyngeal muscles ; 41-44—ventral pharyngeal muscles.

On the posterior side of the head the post-occipital suture is feebly recognised. The extents of occiput and post-occiput are not made out. The maxilla of each side fits in a socket, the hypostoma. The mandibles are present above the maxillae ; they are hinged dorsally and ventrally to the anterolateral margins of the epicranium.

Tentorium

The tentorium (fig. 3) consists of a stout pair of anterior arms. From the latter arise small sclerotised outgrowths the dorsal arms. The posterior arms are short and blunt. The tentorial bridge which receives the anterior and posterior arms is a highly sclerotised and strong structure.

Labrum

The labrum (fig. 4) of the adult *Myrmeleon*, like that of its larva, is flat and broad and a double walled structure.

Musculature.—Extending between the anterior and posterior walls of the labrum are present a pair of small compressor muscles (fig. 4 ; 1). They are situated at the lateral margins of the labrum. A pair of median labral muscles (fig. 4 ; 2) arises from the mid-posterior region of the frons and is inserted on the middle region of the labral base. The lateral labral muscles are paired (fig. 4 ; 3) and each arises from the dorsolateral aspect of the frons to be inserted on the lateral side of the labrum. The disposition of the median and lateral muscles of the adult *Myrmeleon* is almost similar to those of its larva. The position of the compressor muscles in the larva is slightly different than that of its adult ; in the larva they are disposed on the sides of the median cleft of the labrum.

Clypeus

Unlike that of its larva, the clypeus (fig. 1) in the adult *Myrmeleon* is a prominent structure with two distinct portions, a thin and flexible anteclypeus and a highly sclerotised postclypeus. The postclypeus bears a pair of cibarial muscles (fig. 4 ; 4). They are in four to six bundles, have a common origin and are inserted on the epipharyngeal wall of the cibarium (fig. 8 ; 4). Almost equal number of cibarial muscle bundles are present in the larva of *Myrmeleon*.

Mandibles

Each mandible (fig. 5) is well developed and highly sclerotised. It is broad at the base and tapers anteriorly ; it ends in a pointed tooth. A few smaller teeth are also present on the inner side of the mandible. Each mandible possesses two well developed apodemes arising from its dorsal and outer angles.

Musculature.—The lateral mandibular extensor muscle (fig. 5 ; 5) originates from the lateroventral region of gena and is inserted on the outer apodeme. The mandibular flexor muscle (fig. 5 ; 6) originates from the vertex and genal regions of the head, its fibres are roughly arranged in three large groups. The muscle is inserted on the inner apodeme. The mandibles of the adult and larva are similar except in their outer appearance. The mandibular muscles of the larva are comparatively large and powerful. The contraction of these muscles in the larva help the mandibles in piercing the body of the prey while in the adult they are used for grinding and chewing.

Maxilla

The maxilla (fig. 6) is of the generalised type and is composed of a cardo and a stipes. The cardo is divided into a vera-cardo and a juxta-cardo (Crampton, 1916). The stipes is made up of two lobes, an inner and outer. Laterally the stipes bears a five jointed palpus and mesally the galea and lacinia.

Musculature.—The promotor muscle (fig. 6 ; 7) of cardo (cardo-cranial muscle of Kramer, 1955) is fan shaped and is inserted on the apodeme of the vera-cardo. The adductor of the stipes (fig. 6 ; 9) also originates from the anterior tentorial arm and is inserted near the middle region of the stipes. There are two stipito-tentorial muscles ; the upper one is the cephalic stipitotentorial (fig. 6 ; 10) and the lower one is the caudal-stipitotentorial (fig. 6 ; 11). The stipitotentorial muscles originate from the anterior tentorial arm and are inserted on the basal region of the stipes. The stipito-lacinal muscle (fig. 6 ; 12) is the thickest muscle of maxilla. It orignates from the upper one third region of the stipes and is inserted on the basal region of the lacinia. The cranial flexor (fig. 6 ; 13) is long and thin. It originates from the region of the occiput and is inserted on a small apodeme present on the dorsal wall of the lacinia. The galeo-stipital muscle (fig. 6 ; 14) originates slightly above from the base of stipes and is inserted mesally on the base of galea. In the first palpal segment two bundles of short muscles (fig. 15, 16) are present : the inner one (15) is attached on the basal margin of the second palpal segment while outer one (16) is attached on the lateral margin of the same segment. Palpal muscles present in the last four segments (17 to 20) are unpaired. According to Maki (1936) palpal muscles of each segment is made up of two bundles, one levator and the other extensor.

In the larva of *Myrmeleon*, the musculature of maxilla presents a much lower grade of organisation. There are only four extrinsic and two intrinsic muscles. In the adult maxilla, on the other hand, six extrinsic and eight intrinsic muscles are present.

Labium and Hypopharynx

In the adult, unlike that of its larva, the hypopharynx remains coalesced with the surface of the labium (fig. 8). The proximal region of the prementum is sclerotised to form a distinct plate (fig. 2). Just below the latter two lateral sclerotised patches are present which have been termed as anterior sclerite by Snodgrass (1935). A large ligula hangs down from the prementum. The labial palpi are long ; each palpus possesses four distinct segments. The post-mentum appears as a large plate ; its distal part is membranous.

Musculature.—A pair of proximal median ventral muscles (retractor muscles, fig. 7 ; 21) originates from the postmentum ; are inserted medially on the pro-ximal sclerotised plate of the prementum. The dorsal and ventral tentorial adductors (fig. 7 ; 22, 23) originate from the tentorial bridge, near the posterior arm, and are inserted on the dorsal and ventral aspects of the anterior sclerite of the prementum respectively. Within the ligula two very thin muscles on each side (fig. 7 ; 24, 25) are present. They appear to be homologous to the flexors of glossa and paraglossa of an orthopteroid labium. The proximal segment of the labial palpus shows two bundles of muscles (fig. 7 ; 26, 27) while the rest three segments have only one bundle each (fig. 7 ; 28-30).

The hypopharynx is associated with a pair of strong muscles, the hypopha-ryngeal retractor (fig. 8 ; 31). The latter originates from the posterior side of the tentorial bridge and is inserted on a sclerite present within the hypopharynx. A pair of small muscles, muscles of salivos, fig. 8 ; 32) originates from the lateral labial wall and is inserted on the opening of the salivary duct.

The labium in both, larva and adult, shows a similar pattern of muscular organisation except that in the labium of the adult the lateral longitudinal muscles are absent while in the larva muscles of the ligula are absent.

Pharyngeal Muscles

Five bundles of muscles (fig. 8 ; 36 to 40) are inserted on the dorsal wall of the pharynx. All the dorsal pharyngeal muscles arise from the cranium, the first two (36, 37) from the frontoclypeal apotome, the third (38) from the region of the cranium, where the dorsal tentorial arm terminates, and fourth (39) and fifth (40) from vertex and the anterior part of the occiput. To the ventral wall of pharynx only four muscle bundles are attached. The first ventral pharyngeal muscle (41) arises from the posterior tentorial arm, the second and third (42, 43) from the lateral aspect of the gular region and the fourth (44) from the latero-ventral margin of the postocciput. The contraction of the pharyngeal muscles dilate the pharyngeal cavity and as such very often these muscles are designated as dilator muscles of pharynx. In the larva six dorsal pharyngeal muscles and three ventral muscles are present.

Discussion

Ferris (1942, 1944) and Cook (1944) consider that morphological structures are not modified in relation to the work performed. They believe that work is adjusted to the morphological pattern organised by genes. DuPorte (1920, 1946, 1962) and Snodgrass (1947), however, consider that acquisition of morphology is *parri passu* with the functions performed by them.

The plan of musculature of the mandibles of larva and adult *Myrmeleon* is almost identical. Their *modus operaudi* is also similar but the end results in both the cases are different. In the larva the mandibles get pierced into the body of the prey while in the adult no such action is brought about. For accomplishing an effective piercing function it is but natural to expect that the shape of the mandible and the bulk of the mandibular muscles will be modified. The observations in the larva (Srivastava, 1964) point out to this fact.

The ventral adductor muscle of the mandible which normally arises from the anterior tentorial arm in some Orthoptera, Odonata, Ephemeroptera and *Chaulides* in Neuroptera (Maki, 1930) is not present both in the larva and adult *Myrmeleon*. According to Snodgrass (1935) this has given a higher organisational status to the mandible of the adult and larva of *Myrmeleon*. The problem, however, remains that in what way the absence of variation is correlated with the functions of the mandibles of larva and adult *Myrmeleon*.

Four important maxillary muscles (8, 9, 10, 11) of the adult *Myrmeleon* originate from the anterior tentorial arm—a condition identical with that found in many insects e.g. *Stenopsocus* (*Badonnel, 1934), *Ephiophlebia* (Ashina, 1954), *Gryllobatta* (Walker, 1931) etc. The rest of the maxillary muscles originate from the set regions as expected in a generalised plan of insect organisation. However, in the maxilla of the larva of *Myrmeleon* the stipital tentorial muscle, instead of arising from the anterior tentorial arm, like that of its counterpart in the adult, originate from the tentorial bridge. The long maxillary blade of the larva also differs in having only one segment with dorsal and ventral muscles attached to it. The only faesable interpretation of the aforesaid modification appears to be a means to achive perfection in a direction which is unique to the larva.

*C. F. Ryuichi, 1956.

The muscle of the labium in the larva are poorly developed while in the adult there is a normal growth of all the existing labial muscles. The state of affairs in the two (larva and adult) is closely related to the functions they perform. In the larva of *Myrmeleon* the labium is rendered almost functionless except to act as a tight lip which need not be opened frequently. It is very doubtful whether the *Myrmeleon* larva opens its mouth at all. Consequently the restricted function of the labium has brought a direct effect on the apical portion, the ligula, of the labium. The latter forms a sort of a tongue (Ross, 1956) in these insects where the labium functions normally. Since the larva of *Myrmeleon* adopts to a piercing and sucking type of function and the labium is practically non-functional, therefore, there is no utility of ligula and as such it is absent. However, it is interesting to mention that as soon as the adult condition is reached, which incorporates the chewing type of mechanism the ligula appears as usual and performs its set function. It is, therefore, inferred that the acquisition and retention of characters is mainly dependent on the functions performed by them.

Summary

1. The musculature of the head capsule and mouth parts of *Myrmeleon* has been described. A comparison of the muscles of the head of the *Myrmeleon* larva with those of its adult has been made.

2. The structure-function relationship, with particular reference to the cephalic muscles of the larva and adult *Myrmeleon*, has been discussed.

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STUDIES IN AQUATIC FUNGI OF VARANASI

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Introduction

The early knowledge of the Saprolegniaceous fungi was, in modern sense, incomplete and inaccurate. In these earlier accounts of the water molds confusion also persisted with respect to the very nature of these organism. Much of the work from a taxonomic point of view has been done mostly from foreign countries specially in America and Europe. The first comprehensive report on the aquatic fungi (Saprolegniaceae) was made from America by Coker in 1923. This was followed by the isolated papers of Cejp (1932, 1934), Lund (1934), Ivemey-Cook and Morgan (1934), Forbes (1935a, 1935b), Coker and Matthews (1937), Johnson (1956), Sparrow (1960) and Scott (1961). On the other hand few reports from India exist and mention may be made of Butler (1907, 1911), Chaudhuri and Kochhar (1935), Chaudhuri and Lotus (1936), Saksena and Bhargava (1944), Bhargava (1945), Das Gupta and John (1953), John (1955), Dayal (1958) and Srivastava and Bhargava (1963).

The following section of our paper is largely concerned with the details of the methods of isolation, procedure and their identification. Those species which have been collected for the first time from India have been described in detail while others have been only mentioned.

Methods and Material

Technique for collection.—As the water molds reproduce freely by means of zoospores, samples of water in sterilised sample bottles were collected from different localities and sources such as streams, pools, ponds, lakes and ditches, etc., preferably from such sources where no water current exists. Technique for soil sample collection and their subsequent treatment was followed as described by Butler (1911) and Harvey (1925). The samples were immediately brought to the laboratory and a portion of each sample, sufficient to cover the bottom, was transferred to a sterile deep Petri-dish. After this it was baited with halves of boiled hemp seed, small pieces of boiled snake-skin, boiled maize seed, ants, house fly, wheat seed and small fragments of boiled grass blades. Samples were examined after 36–48 hours following "baiting". Each piece of bait was observed microscopically for hyphae and zoosporangial growth characteristic of each genus. Probable and positive isolates were transferred to fresh Petri-dish containing sterile distilled water and additional corresponding baits were added. Pure cultures were obtained according to the technique described by Couch (1939).

All the glass-wares employed in the present study were of Pyrex and have standard dimensions as described by Emerson (1958).

[309]
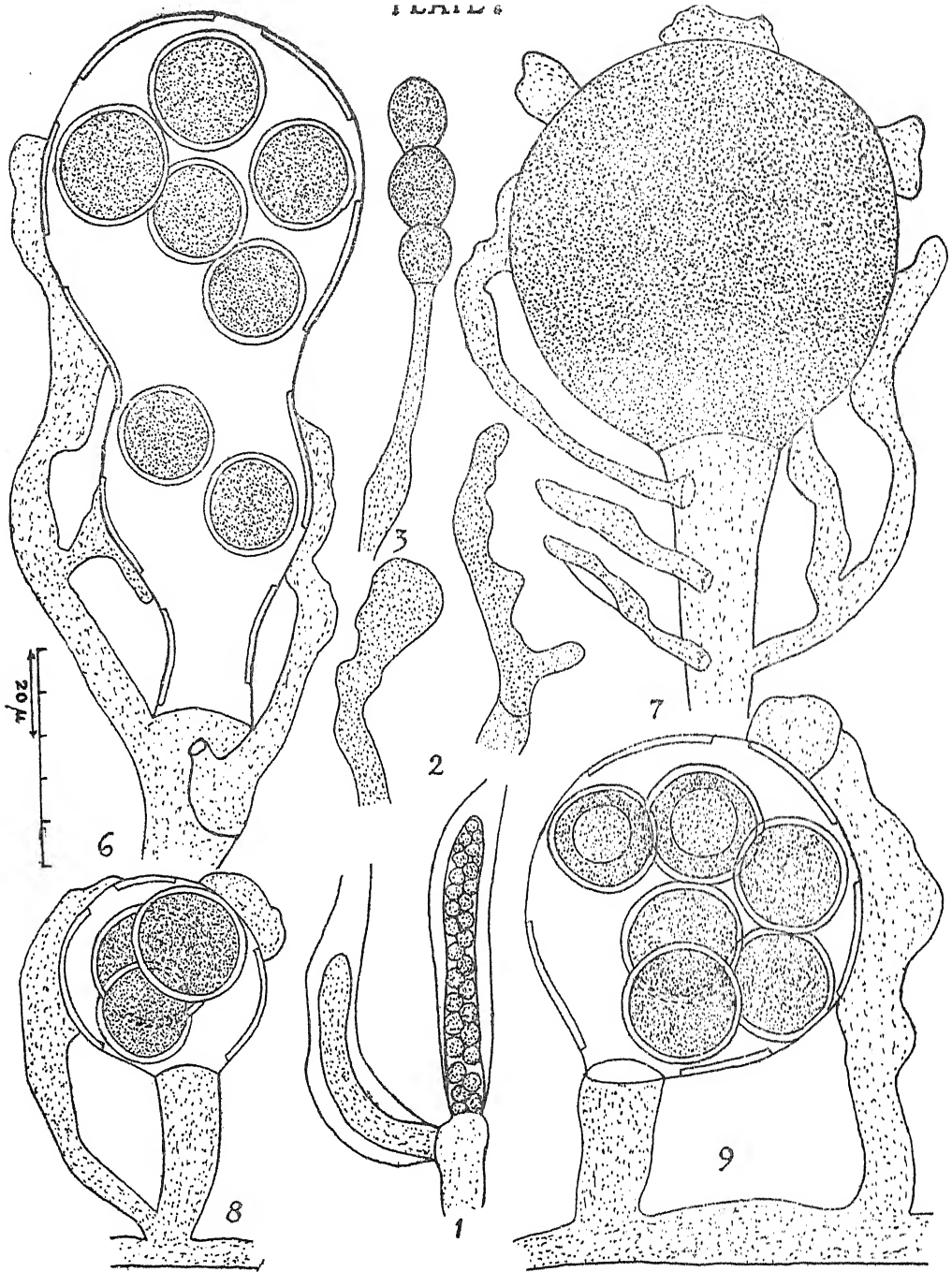
Saprolegnia litoralis

Fig. 1. An young and mature sporangia showing proliferation X100.
Figs. 2 & 3. Various forms of gemmae X100.
Fig. 6. Terminal oogonium with antheridia.
Fig. 7. Immature oogonium.
Fig. 8. Oogonium with androgynous antheridium
Fig. 9. Oogonium with centric eggs.

PLATE 2
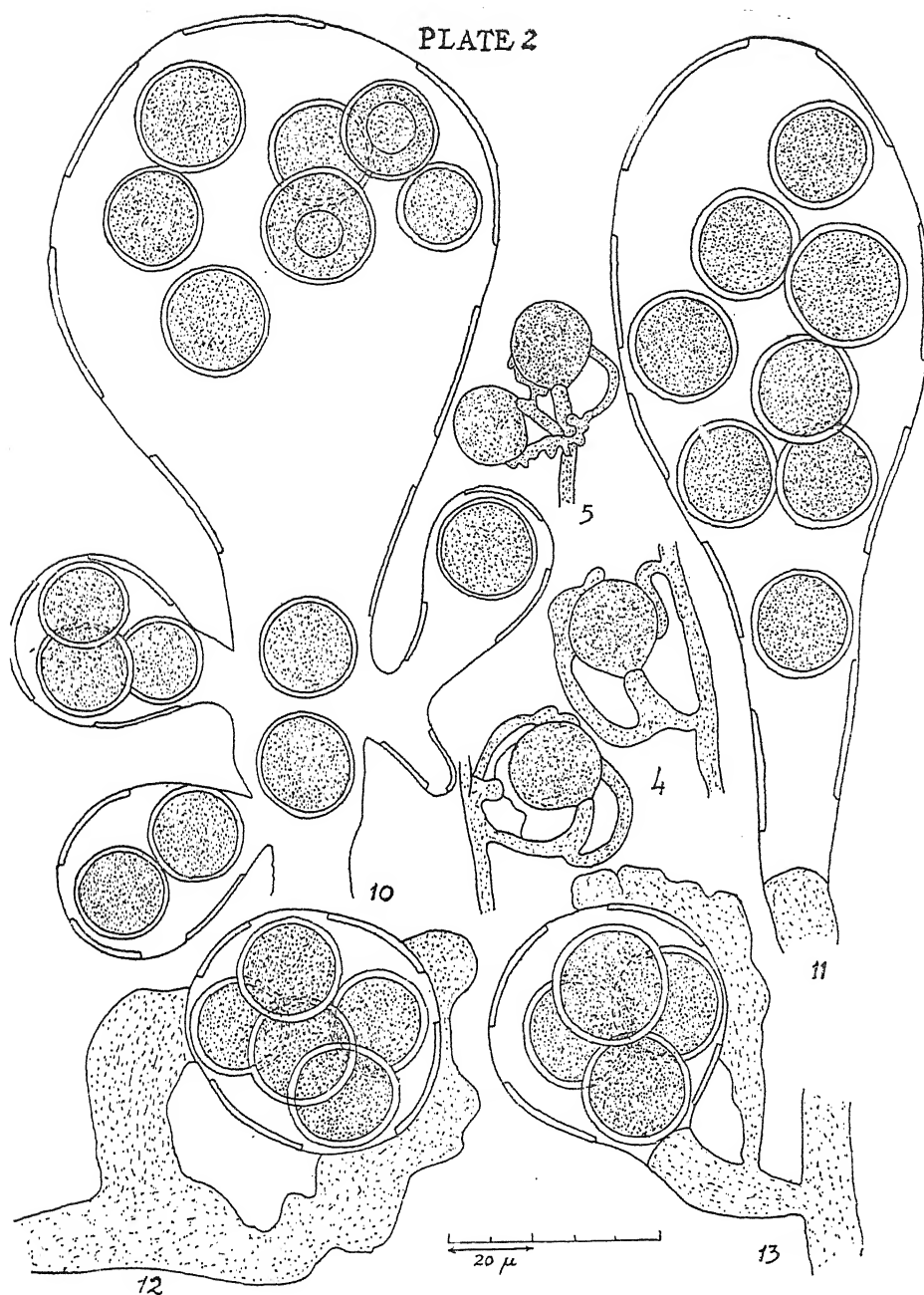
Saprolegnia litoralis

Figs. 4 & 5.   Habit of fruiting X100.
Fig. 10.   Odd shaped oogonium with centric eggs.
Fig. 11.   Apical oogonium without antheridium.
Fig. 12.   A short-stalked oogonium.
Fig. 13.   Oogonium with androgynous antheridium.

PLATE 3
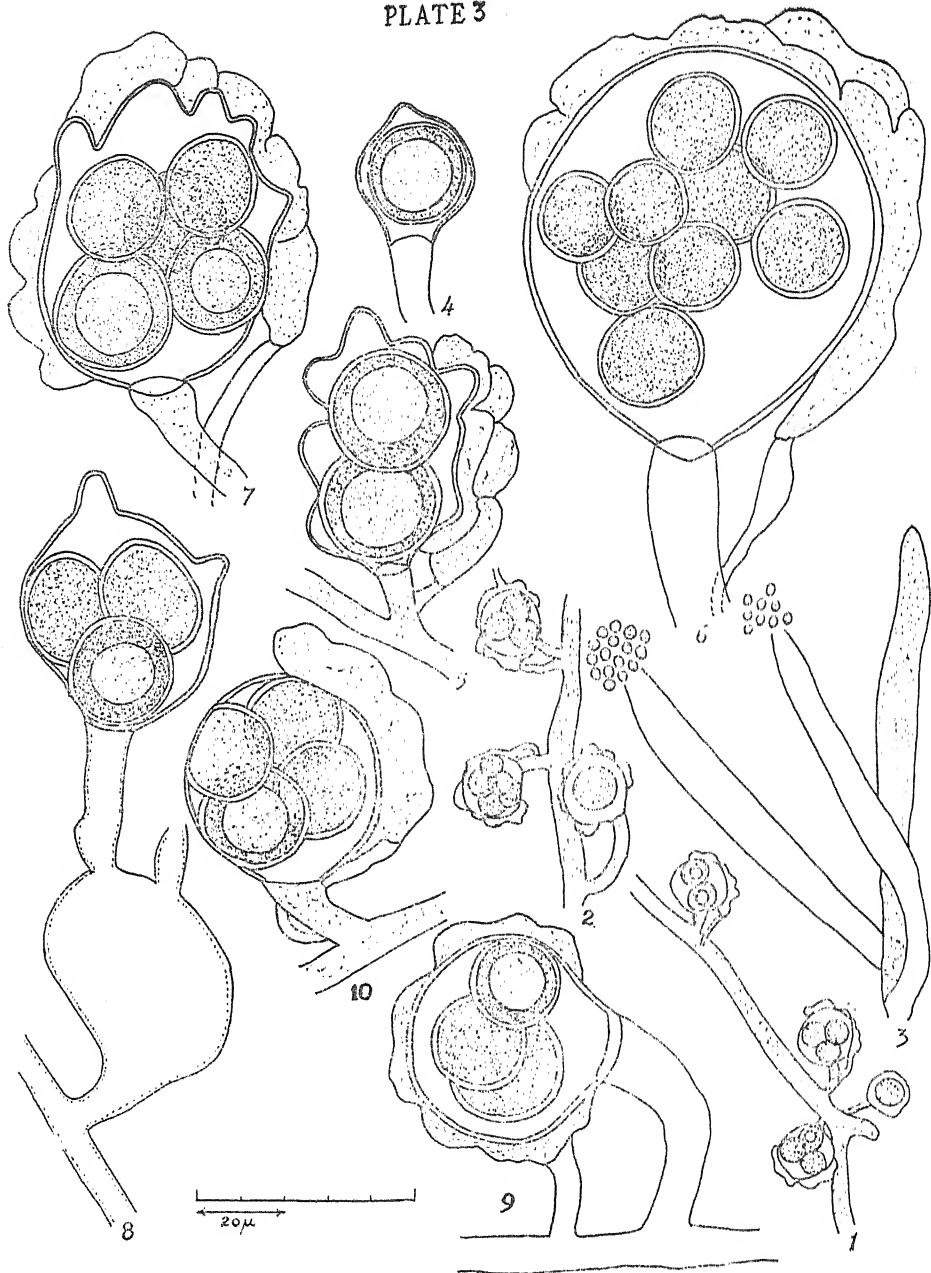
Achlya oligacantha

Figs. 1 & 2.   Habit of fruiting X100.
Fig. 3.   A typical sporangial cluster X100.
Fig. 4.   Typical oogonium with single egg.
Fig. 5.   Oogonium with androgynous antheridia.
Fig. 6.   Smooth walled oogonium with various ripe eggs.
Fig. 7.   Oogonium of odd shape with small papillae.
Fig. 8   Two oogonia, one attached with a long stalk while other empty.
Fig. 9.   Oogonium with curved stalk and monoclinous antheridium.
Fig. 10.   Normal oogonium with androgynous antheridia.

PLATE 4
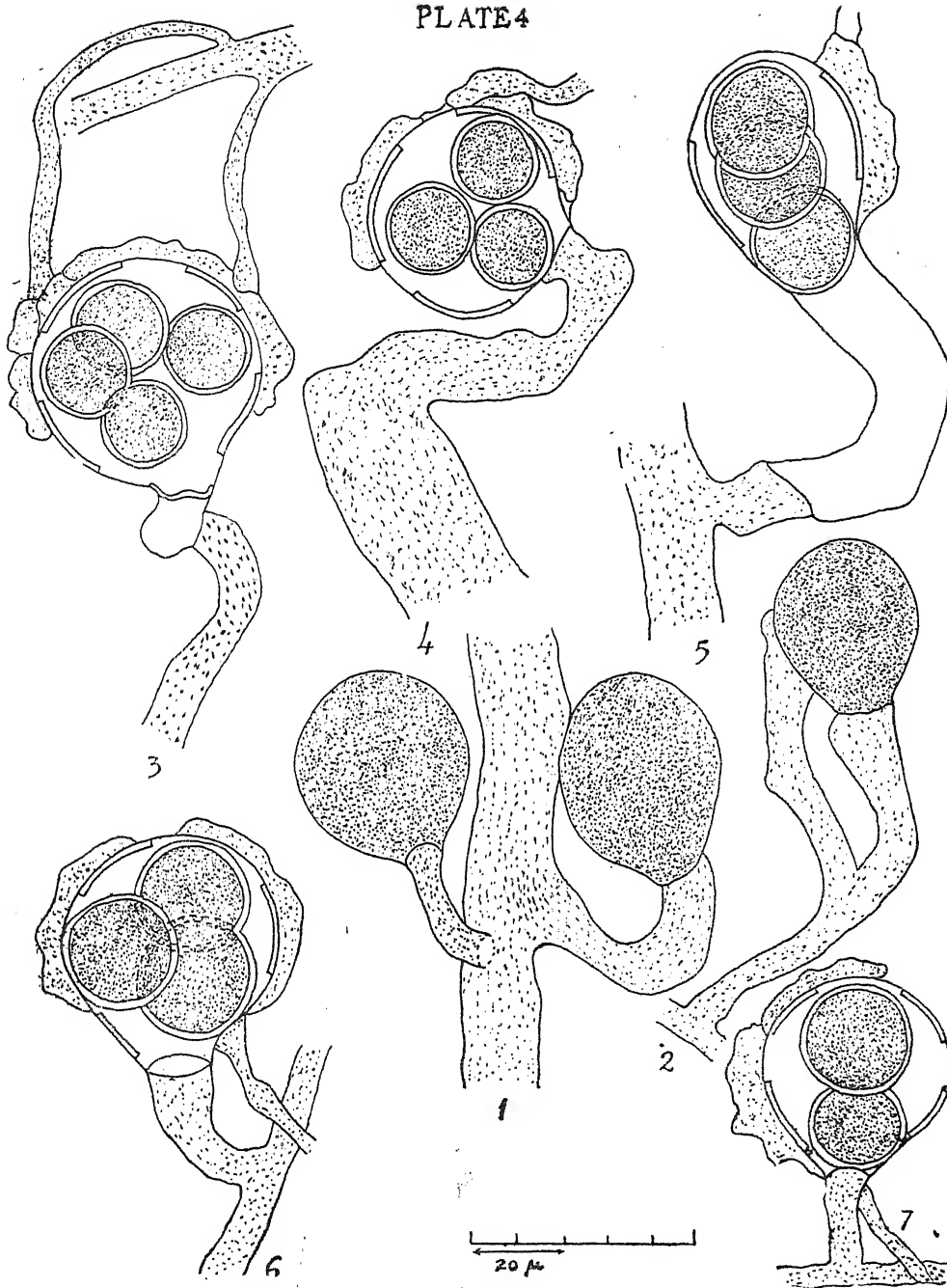
Achlya proliferoides

Fig. 1. Habit of oogonia X100.
Fig. 2   Long stalked oogonium with androgynous antheridia X 100.
Fig. 3. Pitted oogonium with diclinous antheridium.
Fig. 4. Oogonium on a broad bent hyphae.

PLATE 5
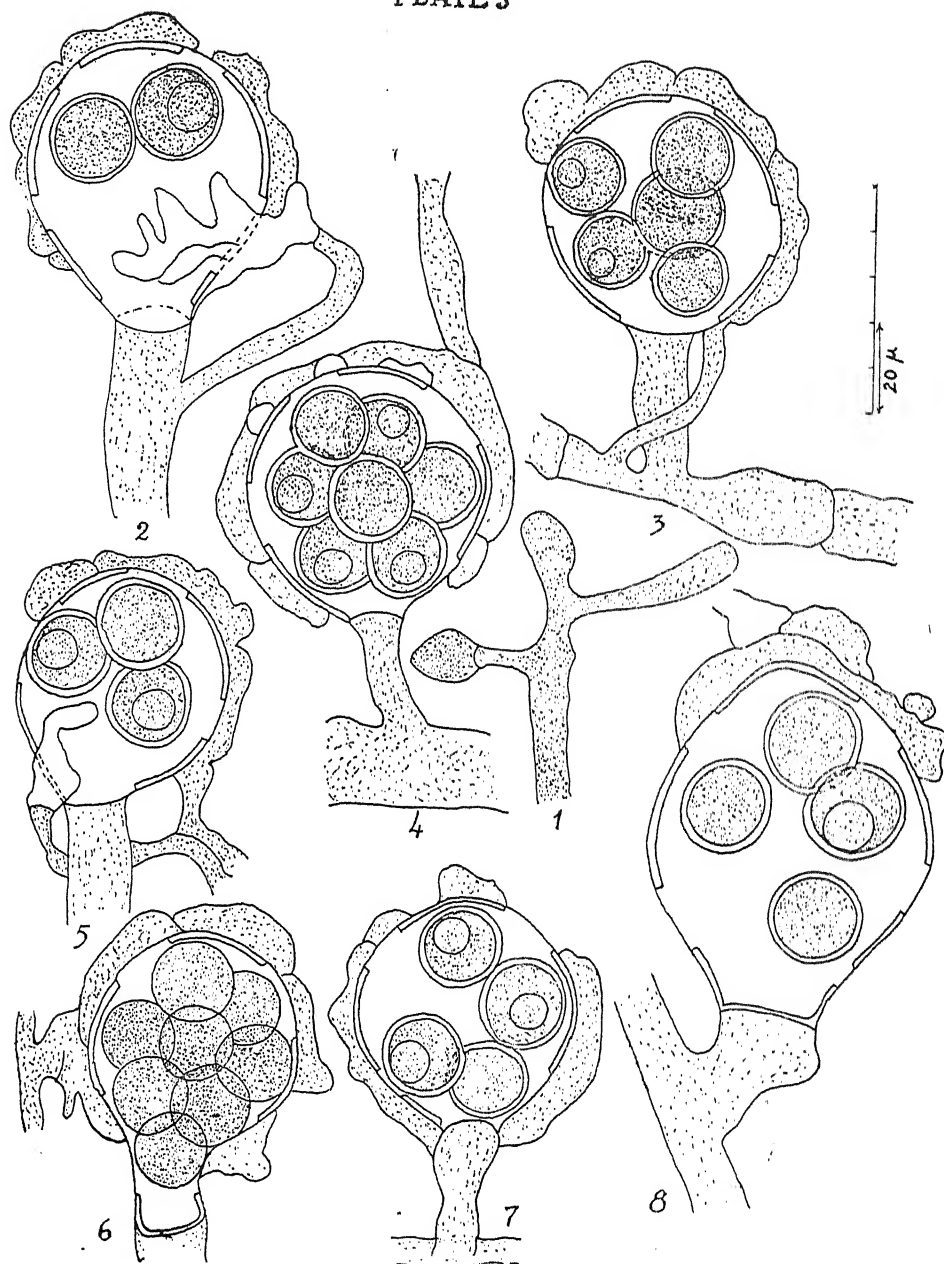
Achlya prolifera

Fig. 1. Different forms of soprangia X100.
Fig. 2. Oogonium with antheridial tubes after the antheridia have emptied.
Fig. 3. Oogonium with eccentric eggs.
Fig. 4. Oogonium with diclinous antheridium.
Fig. 5. Oogonium with branched antheridium.
Figs. 6—8. Various shape of oogonia with varying number of eggs.

PLATE 6
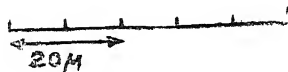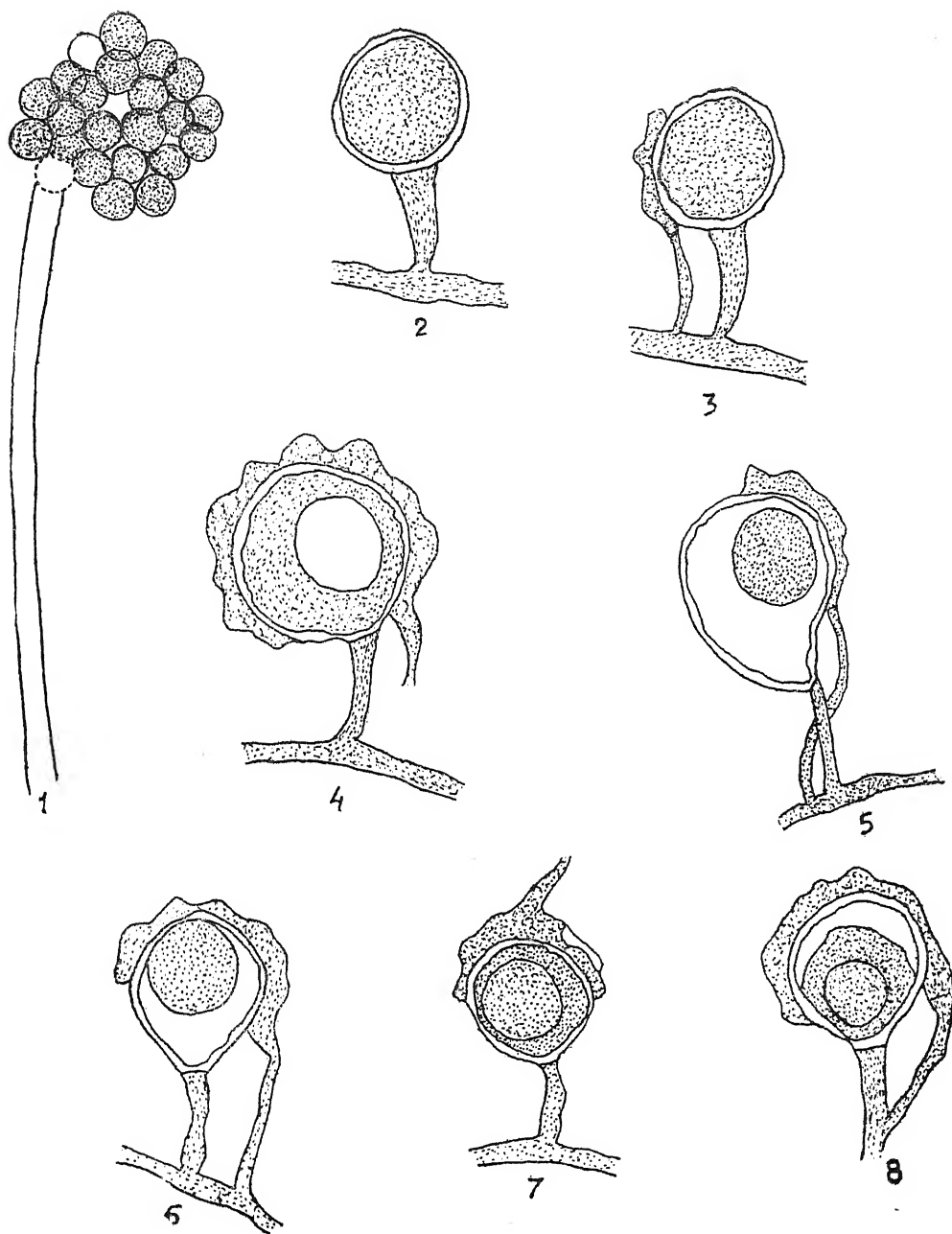
Aphanomyces cladogamus

Fig. 1. Spores encysting on the tip of sporangium.
Figs. 2 & 3. Oogonium with and without antheridia of androgynou nature.
Figs. 4 & 7. Antheridia of diclinous origin with an eccentric egg. s
Figs. 5 & 6. Oogonia with inner irregular thickened walls.
Fig. 8. Eccentric egg within smooth oogonial wall.

PLATE 7
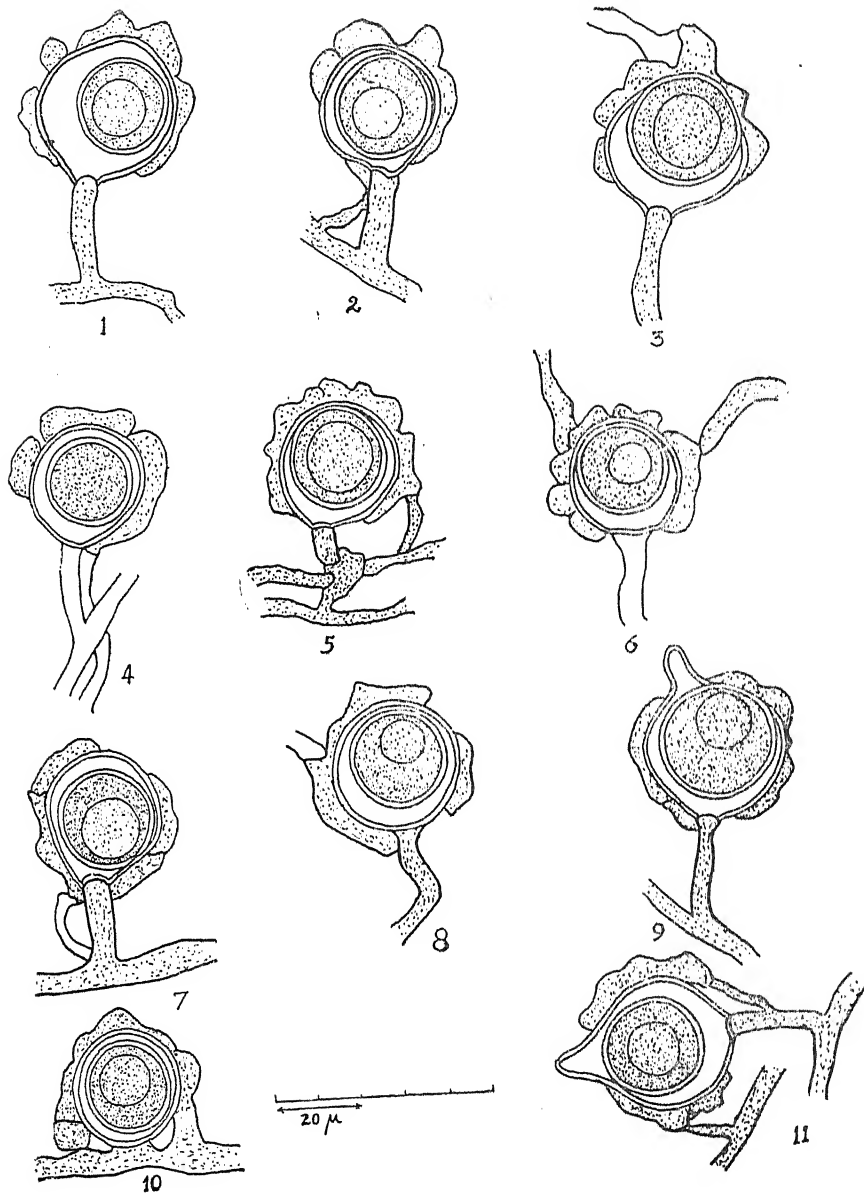
Aphanomyces petersonii

Fig. 1.   Smooth walled oogonium.
Fig. 2. Oogonium with androgynous antheridium.
Fig. 3.   Oogonium with diclinous antheridium.
Fig. 4.   Oogonium receiving a long stalked antheridium.
Fig. 5.   Oogonial stalk arising from a hyphal 'knot' swelling.
Fig. 6.   Oogonium with both diclinous and androgynous antheridia.
Figs. 7 & 8.   Oogonia with different antheridia.
Fig. 9.   Oogonium with blunt apical papilla.
Fig. 10. Sessile oogonium clapsed by antheridium.
Fig. 11. Oogonium with both androgynous and diclinous antheridia.

Experimental

Twenty three of the aquatic fungi, primarily with the object of their proper systematic study, have been isolated from the various ponds surrounding the University Campus of Varanasi. The fungi isolated were *Saprolegnia delica, S. diclina, S. mixta, S. monilifera, S. ferax, S. litoralis, S. parasitica ; Isoachlya toruloides, I. monilifera ; Achlya flagellata, A. racemosa, Achlya sp., A. oligacantha, A. colorata, A. imperfecta, A. proliferoides, A. prolifera, A. conspicua ; Dictyuchus sterile ; Aphanomyces laevis, A. cladogamus, A. petersonii* and *Allomyces arbuscula.*

Description of the species

Saprolegnia litoralis Coker.   The Saprolegniaceae 54 p., 1923.

Vegetative growth similar to *S. ferax*, more vigorous and irregular. Sporangia not plentiful, young ones almost cylindrical or more often irregular in diameter, usually curved, repeatedly proliferating. Gemmae very abundant, spherical, pyriform, clavate, etc., often in chains. Oogonia abundant as a rule approaching about $51–145.2\mu$ in diameter ; the large number terminal on main hyphae, others on short lateral branches, usually spherical in shape, furnished with rather few, very conspicuous pits. Eggs centric, large and dark, 3–30, mostly 4–7 in an oogonium, their diameter $20.4–30.6\mu$, most about $23.8–27.2\mu$; often elliptic from pressure. Antheridia on every oogonium (one to several), androgynous on short branches which originate very near the oogonium, frequently, when the oogonium is on a short stalk, arising from immediately below it. (Plates 1–2, Figs. 1–13).

Achlya oligacantha deBary.   Bot. Zeit. 46 : 647, 1888.

Main threads slender and delicate. Oogonia on short or long branches of hyphae which are furnished with sporangia or in part terminal on slender main threads and their racemose branches, spherical in shape varying from $34–88.4\mu$ in length and $27.2–81.6\mu$ in breadth ; surface always with relatively large, smooth, papillae, measuring about $3.4–10.2\mu$ in length, separated from each other and which vary greatly in number (one to seven, very seldom none) ; also variable in size and form (short points to large, blunt projections) ; walls of oogonia relatively thin, colourless, without pits except that the projections are mostly thinner than the walls between them. Eggs centric, mostly 3–5 in an oogonium (seldom up to 9 or more), round, relatively small $17–34\mu$ in diameter. Antheridia always present, mostly several on each oogonium, relatively small ; borne one or two in a row, some are mostly partly androgynous while others partly diclinous in origin. (Plate 3, Figs. 1–10).

Achlya proliferoides Coker.   The Saprolegniaceae 115 p., 1923.

Growth moderately dense and strong. Hyphae moderately branched, variable in size, usually wavy and irregular. Sporangia subcylindrical, usually bent, often provided with several openings, long or short as a rule. Oogonia abundant, spherical, smooth, $40.8–51.0\mu$ in diameter, racemosely brone on stalks that are about 1 to $1\frac{2}{3}$ times as long as the diameter of the oogonia ; walls hyaline, not thick, pits numerous (usually) but not very conspicuous. Eggs eccentric with a large oil drop, usually elliptic, about 20.4μ in diameter. Antheridial branches numerous, diclinous or androgynous, usually long, contorted and much branched. Antheridia one or several, on every oogonium, elongated applying their sides to the oogonium or touching it by serveral blunt, foot-like processes. (Plate 4, Figs. 1–7).

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Achlya prolifera (Nees) deBary.   Bot. Zeit. 10 : 473, 1852.

Main threads, stout, usually ending with primary sporangia. Oogonia racemosely arranged on short side branches of the main hyphae, as a rule terminal, round, the walls with numerous, very sharply defined and obvious pits. Eggs variable in number from 3–7, eccentric, 13·4–27·2μ in diameter. Antheridial branches mostly diclinous, much twisted and branched, winding like a parasite about the oogonia. The oogonial walls thickly enwrapped and often completely covered by these branches which bear numerous antheridia, which send their sides against the oogonium and send out fertilizing tubes. (Plate 5, Figs. 1–8).

Aphanomyces cladogamus Drechsler.   J. Agric. Res. 38 : 335, 1929.

Hyphae 3·4–6·8μ in diameter, delicate, hyaline. Zoosporangia very large, often extensive involving the conversion of large segments of vegetative hyphae, not tapering towards the apex, zoosproes encysting at the orifice upon emergence. Oogonia terminal on short lateral branches of variable length, subspherical to glubose 40·8μ in diameter, mostly averaging 28·9μ. Walls irregulary thickened with a smooth outer surface. Oospore single, hyaline, 13·6–23·8μ in diameter, thick walled, contents granular and with a small conspicuous refractive body in the centre. Antheridia 2–3 consisting of an inflated portion of variable length. Antheridial stalk long diclinous or monoclinous in origin. Germination of the oospore could not be seen. (Plate 6, Figs. 1–8).

Aphanomyces petersonii Scott.   The Virginia Journal of Science 7 : 171, 1956.

Hyphae up to 7·2μ in diameter, intramatrial, sparingly branched, ramifying throughout the body cavity of the host, zoopsporangia long, filamentous, unbranched, of the same diameter as the vegetative hyphae, isodiametric, penetrating the host wall and extending at right angles into the surrounding medium, zoospores rod shaped, few in number encysting at the orifice, discharge schistose, secondary zoospore reniform. Oogonia terminal on short lateral branches, spherical, 23·8–37·4μ in diameter, smooth walled ; oospore 20·4–30·6μ in diameter, hyaline, content granular with a single large oil globule. Antheridia single, swollen clavate ; antheridial stalk simple, unbranched, diclinous in origin. Oospore germination not observed. (Plate 7, Figs. 1–11).

Summary

Twenty three different species belonging to different orders of Phycomycetes have been isolated and described from Varanasi. An attempt was made to examine as precisely as possible the character of individual organisms.

From the literature available it appears that the *Saprolegnia litoralis* ; *Achlya oligacantha, A. proliferoides, A. prolifera* ; *Aphanomyces cladogamus* and *A. petersonii* are new records from India.

Acknowledgments

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SOIL MICRO-FUNGI OF BLACK WATTLE FOREST AT YERCUD (SALEM SOUTH FOREST DIVISION) MADRAS STATE IN RELATION TO *GUMMOSIS* DISEASE

By

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The influence of surface vegetation on the composition of soil microflora is well known, be it a forest cover (Chauhan 1960, Saksena 1955, Sharma 1965, Shetye 1954, Tresner *et al.* 1954) or agricultural crop (Guillemat and Montegut 1956, 1957 and 1958). This is partly due to the various edaphic factors and to the rhizosphere and rhizoplane effects of different species of higher plants.

The Black Wattle (*Acacia mollissima* Willd.) is a native of South Australia and Tasmania. It was introduced in South India (Loc : Prospect Estate near Waduvattam in Kodaikanal) along with Silver Wattle (*Acacia dealbata* Link.) in 1840 from South Africa.* The Forest Department of Madras State started wattle plantation around 1939. The present acreage of wattle plantations in Madras State is fairly extensive.

The bark of black wattle is one of the richest vegetable tanning material known to the tanning industry. The amount of non-tannins is proportionately low which makes the bark superior to other tanning materials. The black wattle grows on a wide variety of soil but its growth is rapid on loose, deep, well drained soil. The optimal soil requirements are provided in sites having dark sandy loam or red loam on gentle slopes.

The plant is susceptible and suffers heavy casualities specially among older plants (six years and above) from an obscure pathological condition known as "*Gummosis*" or "Bleeding". The disease is easily noticeable from free exudation of gum from boles of trees and black mottling of the bark. The bark of the affected tree gradually dries up and becomes brittle. Such affected trees ultimately die rendering the bark useless as tan-bark (Plates 1, 2 and 3).

The present investigation deals with the comparison of soil micro-fungi and some soil conditions around the healthy and diseased plants of *Acacia mollissima*. For that random soil samples, collected from the vicinity of diseased and healthy trees from an abandoned black wattle plantation at Yercud (Salem South Forest Division) were studied.

Materials and Method

Soil samples were collected around the healthy plants (designated as "A") and diseased plants (designated as "B") separately by means of sterilized borer, stored in sterilized polythene bags and brought to the laboratory for further investigations.

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*Cited from the Wealth of India, Vol. I, 1948, p. 17.

The fungal flora of the samples was determined both quantitatively and qualitatively using dilution plate method of Waksman (1927). Three dilutions *viz.*, 1 : 100, 1 : 1000 and 1 : 10,000 and Martin's Rose-Bengal Streptomycin (Allen 1951) and Czapek's agar media were used. The inoculated plates were incubated at room temperature (28°–32°C) for about a week. Fungal colonies appearing on the plates were counted and transferred after purification on Czapek's agar. The isolates were identified and the identification was confirmed by reference to the Commonwealth Mycological Institute, Kew, England. The total population, frequency and abundance of fungi were determined. Soil factors were determined using standard methods.

Results

The species of fungi isolated from soils "A" and "B" together with their population, frequency and abundance are given in Table I. The result of the tests for various physical factors and chemical analysis is presented in Table II.

TABLE I

Distribution, population, frequency and abundance of species of fungi isolated from soil of healthy and diseased plants of Acacia mollissima

S. No.	Name of species	Soil from the heathy plants			Soil from the diseased plants		
		*Population	Frequency	Abundance	*Population	Frequency	Abundance
1.	*Rhizopus arrhizus* Fischer	0·250	2·5	0·213	–	–	–
2.	*Mucor hiemalis* Wehmer	1·250	12·5	1·066	0·500	5·0	1·153
3.	*Syncephalastrum racemosum* (Cohn) Schroeter	6·500	12·5	5·544	0·500	5·0	0 769
4.	*Thielavia terricola* (Gilman and Abbott) Emmons	1·250	10·0	1·066	–	–	–
5.	*Chaetomium globosum* Kunze	2·500	2·5	0·213	0·750	5·0	1·153
6.	*Neocosmospora vasinfecta* E. F. Smith	0·500	5·0	0·426	–	–	–
7.	*Sordaria fimicola* (Rob.) Ces. and DeNot	–	–	–	0·500	5·0	0·769
8.	*Phoma* sp.	0·250	2·5	0·213	0·500	5·0	0·769
9.	*Pestalotia* sp.	0·500	5·0	0·426	0·500	5·0	0·769
10.	*Trichoderma lignorum* (Tode) Harz	0·750	7·5	0·637	5·500	25·5	8·461
11.	*T. koningi* Oudemans	5·250	32·5	4·477	1·750	12 5	2·692
12.	*Aspergillus fumigatus* Fres. (str. 1)	1·000	10·0	0·852	0·250	2·5	0·384
13.	*A. fumigatus* Fres. (str. 2)	0·250	2·5	0·213	–	–	–
14.	*A. nidulans* (Eidam) Winter	0·250	2·5	0·213	0·750	7·5	1·153
15.	*A. sydowi* (Bainier and Sartory) Thom and Church	0·750	5·0	0·637	–	–	–

S. No.	Name of species	Soil from the healthy plants			Soil from the diseased plants		
		*Population	Frequency	Abundance	*Population	Frequency	Abundance
16.	A. flavus Link (str. 1)	0·500	5·0	0·426	0·250	2·5	0·384
17.	A. flavus Link (tr. 2)	–	–	–	0·250	2·5	0·384
18.	A. terreus Thom	1·000	10·0	0·852	–	–	–
19.	A. ustus (Bainier) Thom and Church	1·000	10·0	0·852	–	–	–
20.	A. luchuensis Inui	0·500	5·0	0·426	–	–	–
21.	A. niger van Tiegham	0·750	7·5	0·637	0·750	7·5	1·153
22.	A. sulphureus (Fres.) Thom and Church	–	–	–	0·250	2·5	0·384
23.	A. candidus Link	0·250	2·5	0·213	–	–	–
24.	Penicillium citrinum Thom	10·000	40·0	8·528	1·000	10·0	1.538
25.	P. stekii Zateski	7·000	22·5	5·970	0·500	5·0	0·769
26.	P. egyptiacum van Beyma	1·250	12·5	1·066	0·250	2·5	0·384
27.	P. lilacinum Thom	2·750	20·0	2·345	1·750	15·0	2·692
28.	P. janthinellum Biourge	4·250	17·5	3·624	5·250	17·5	8·076
29.	P. simplicissimum (Oudemans) Thom	6·500	2·5	1·066	0·250	2·5	0·384
30.	P. nigricans Bainier	4·000	22·5	3·411	0·500	5·0	0·769
31.	P. wortmanii Kloecker	–	–	–	0·750	5·0	1·150
32.	P. funiculosum Thom	0·500	2·5	0·426	–	–	–
33.	P. spiculisporum Lehman	6·500	12·5	5·544	0·250	2·5	0·384
34.	P. vermiculatum Doug.	4·750	12·5	4·051	0·250	2·5	0·384
35.	P. megasporum Orport and Fennell	0·500	2·5	0·426	–	–	–
36.	Penicillium sp.	–	–	–	0·750	5·0	1·153
37.	Gliocladium roseum (Link) Thom	–	–	–	0·500	5·0	0·769
38.	Gliocladium sp.	–	–	–	0·250	2·5	0·384
39.	Thielaviopsis sp.	–	–	–	0·250	2·5	0·384
40.	Stachybotrys atra Corda	0·500	5·0	0·426	0·250	2·5	0·384
41.	Humicola fusco-atra Traaen (str. 1)	2·000	15·0	1·705	1·500	10·0	2·307
42.	H. fusco atra Traaen (str. 2)	8·000	32·5	6·823	2·800	12·5	3·076
43.	Cladosporium sp.	2·250	20·0	1·916	1·500	7·5	2·307
44.	Curvularia verruculosa Tondon and Bilgrami	1·250	7·5	1·066	0·500	5·0	0·769
45.	Alternaria tenuis Nees ex Pers.	2·250	15·0	1·916	0·750	7·5	1·153
46.	Fusarium oxysporum Schlecht	15·250	32·5	13·006	14·750	47·5	22·538
47.	F. solani (Mart.) App. and Wr.	20·000	55·0	17·057	18·250	40·0	28·076
	Total	124·750			60·000		

*Population in thousands per gm.   – Indicates absence.
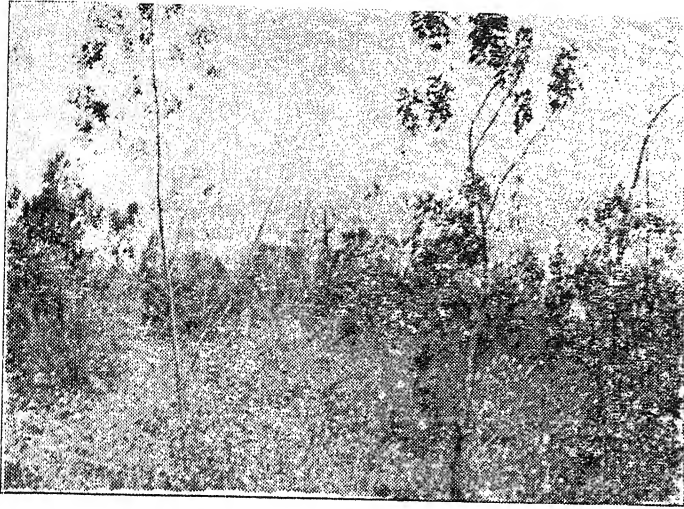
PLATE 1. Showing Healthy (A) stands of *Acacia mollissima*.

PLATE 2. Showing 'Diseased' (B) stands of *Acacia mollissima*.
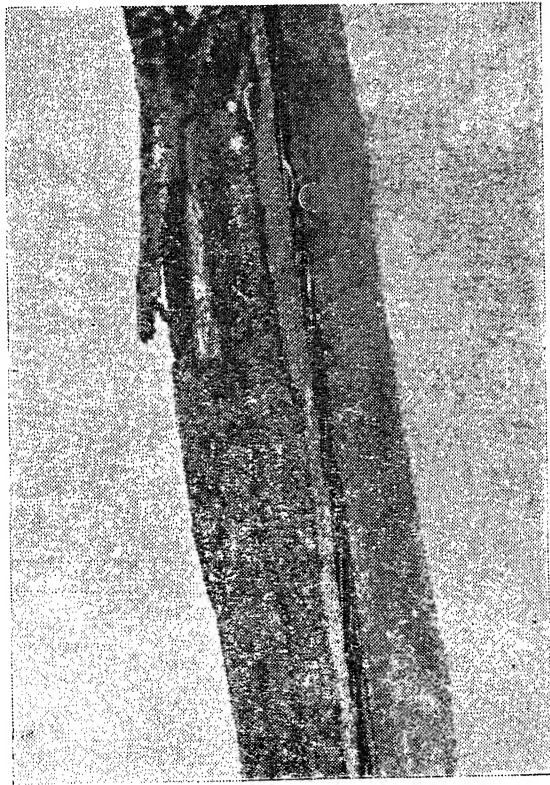
PLATE 3. 'Diseased' bark of *Acacia mollissima*.

TABLE II

Showing the various physical factors and chemical analysis of soil of healthy and diseased plants of Acacia mollissima

(% on dry-weight basis)

Estimations	Soil from healthy plants	Soil from diseased plants
Total moisture	22·610%	17·996%
Moisture content (in air dry soil)	3·95%	3·74%
Loss on ignition	16·165%	11·987%
Insoluble residue	57·335%	58·978%
pH	6·80	6·92
Organic carbon	1·184%	1·077%
Iron as Fe_2O_3	9·326%	11·328%
Alumina (Al_2O_3)	14·778%	11·274%
Calcium (CaO)	0·2750%	0·3635%
Magnesium (MgO)	0·06205%	0·05799%
Phosphorus (P_2O_5)	0·1533%	0·1453%
Potassium (K_2O)	0·4868%	0·4482%

Discussion

The data presented in Table I reveals that the fungal population in soil "A" (124·750) is much higher than in soil "B" (60·000). The number of species isolated from soil "A" is also higher than the number of species isolated from soil "B" being 39 and 36 respectively. Out of these, twenty-eight species are common to both the types of soil but 11 species *viz.*, *Rhizopus arrhizus*, *Thielavia terricola*. *Neocosmospora vasinfecta*, *Aspergillus fumigatus*, *A. sydowi*, *A. terreus*, *A. ustus*, *A. lichuensis*, *A. candidus*, *Penicillium funiculosum*, *P. megasporum* were exclusively present in soil "A" and 8 species *viz.*, *Sordaria fimicola*, *Aspergillus flavus*, *A. sulphureus*, *Penicillium wortmanii*, *Penicillium* sp., *Gliocladium roseum*, *Gliocladium* sp., *Thielaviopsis* sp., were confined only to soil "B".

In all, a total of 47 species have been isolated from soil of both the types, including 3 members of Phycomycetes, 4 of Ascomycetes, one each of Sphaeropsidales and Melanconiales and 38 species of Moniliales.

Fusarium oxysporum and *F. solani* are the two most abundant species in both the types of soils. However, their values for abundance are higher in "B" than in "A". Similarly *Trichoderma lignorum* and *Penicillium janthinellum* had higher abundance in "B" than in "A". On the other hand *Syncephalastrum racemosum*, *Trichoderma koningi*, *Penicillium citrinum*, *P. stekii*, *P. spiculisporum*, *P. vermiculatum*, *Humicola fusco-atra* (str. 2) had higher abundance in "A" than in "B", thus showing reverse behaviour.

The highest percentage frequency in soil "A" is shown by *Fusarium solani* followed by *Penicillium citrinum*, *Trichoderma koningi*, *Humicola fusco-atra* (str. 2) and *Fusarium oxysporum*. *Fusarium oxysporum* followed by *F. solani* and *Trichoderma lignorum* show the higher percentage of frequency in soil "B".

The physical and chemical characteristics of the soil such as soil moisture, organic carbon, nitrogen content, exchangeable calcium, pH values influence the

development of soil micro-fungi and higher values of these factors favour their growth (Waksman 1927, Jensen 1931, Warcup 1952, Saksena 1955, Chauhan 1960). A perusal of Table II will indicate a negligible difference in the soil factors of both the types of soil, which probably is responsible for similar type of fungal flora in both the soils. The well marked difference between the total population of fungi in two types of soils suggests that it is influenced by the roots of the healthy or the diseased plants more than by the edaphic factors.

Summary

Soil micro-fungi and soil factors of the healthy plants ("A") and diseased plants ("B") of *Acacia mollissima* have been investigated. The data obtained showed marked difference in the total population of micro-fungi of the two soils though the fungal membership is almost the same. There is not much difference in the physical and chemical characteristics of the two soils.

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*Original not seen.

CONTRIBUTION TO THE EMBRYOLOGY OF *EUPHORBIA PELTATA* ROXB.

By

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Introduction

Euphorbiaceae are well known for their variation in embryological features (Banerji, 1949 ; 1951 ; Caesca, 1961 ; Johri and Kapil, 1953 ; Kajale, 1954 ; Kapil ; 1960 ; 1961 ; Landes, 1946 ; Mukherjee, 1957 ; 1961 ; Nair, 1962). This extensive work shows a range of embryological characters, particularly in the mode of embryo sac development ; it is monosporic, bisporic and tetrasporic with as many as six types of embryo sac development under the tetrasporic type. Likewise the embryo development follows three main types of Johansen (1950). These are the Scabiosa variation of the Piperad type ; the Onagrad type with three variations, *viz.,* the Euphorbia variation, the Lotus variation and the Onagrad variation ; and the Linum variation of the Solanad type. The embryological feature of *Euphorbia peltata* Roxb. are described in this paper.

Material and Methods

The material was collected and fixed in F. A. A. by Prof. A. T. Kapuskar of College of Science, Nagpur, during a botanical excursion to Ootacamund. Usual methods were followed for embedding the material. Sections were cut 8–10 microns in thickness. The seeds were boiled in wax kept in a hot water bath for about 6–8 hours. This facilitated the proper infiltration of the wax. They were stained with iron alum haematoxylin and destained in a saturated solution of picric acid. Some sections were counter stained with fast green.

Microsporogenesis and Male Gametophyte

The hypodermal archesporium arises at corners in the young anther and consists of two to three longitudinal rows of cells which extend over the entire length of each anther lobe (Fig. 1). It cuts off the primary parietal layer below the epidermis and the primary sporogenous layer on the inner side (Fig. 2). The parietal layer by further divisions forms three layers (Fig. 3). Of these, the middle layer degenerates during the early stages of anther development (Fig. 4). The inner most layer forms the tapetum which is of the secretory type (Figs. 3, 4). The tapetal cells become binucleate (Figs. 4, 5) and degenerate as the pollen grains reach maturity. Tiny crescent shaped granules staining yellow with haematoxylin were observed along their inner tangential walls (Fig. 5). The outer most parietal layer develops into the fibrous endothecium. Granules similar to those present on tapetum were also observed in this layer (Fig. 6). Anther dehiscence is similar to *Euphorbia hypericifoilia* and *E. dracunculoides* (Mukherjee, 1957, 1961).

Figures 1—34. *Euphorbia peltata*. Fig. 1. T. S. anther lobe showing multicellular arches-porium X 1800. Fig. 2. T. S. anther lobe showing sporogenous cells and parietal cells X 1800. Fig. 3. T. S. anther lobe showing four layers of anther wall X 1800. Fig. 4. The same showing degenerating middle layer and binucleate tapetum X 1800. Fig. 5. Part of the binucleate tapetum and uninucleate pollen grains, note the deposition of yellow crescent shaped granules on the inner wall of the tapetum X 1800. Fig. 6. Part of fibrous endothecium showing the deposition of granules and degenerating remains of the middle layer X 1800. Figs. 7, 8. 2-nucleate and 3-celled pollen grains respectively X 1800. Fig. 9. L. S. ovule showing obturator entering the micropyle X 900. Fig. 10. Nucellus showing multicellular archesporium X 1800. Fig. 11. Megaspore mother cell and parietal cells X 1800. Fig. 12. Linear tetrad and formation of primary and secondary parietal tissues X 1800. Fig. 13. Embryo sac showing egg apparatus, 2 polar nuclei and 3 antipodals X 1800. Fig. 14. L. S. micropylar part of the embryo sac showing egg and pollen tube X 1800. Figs. 15-26. Stages in development of embryo X 1800. Fig. 27. L. S. mature seed X 900. Fig. 28. Embryo sac showing free nuclear endosperm X 1800. Fig. 29. Diagrammatic representation of embryo sac showing cellular endosperm, note the degenerating nucellar beak and hypostase X 700. Figs. 30-32. Stages in development of seed coat X 1800. Figs. 33, 34. Stages in development of pericarp X 1800.

ABBREVIATIONS

Cot—Cotyledons ; *Dg nb*—Degenerating nucellar beak ; *End*—Edosperm ; *Hy*—Hypostase ; *Ii*—Inner integument ; *Mem*—Membrane ; *Ob*—Obturator ; *Oi*—Outer integument ; *Pt*—Pollen tube ; *Rc*—Root cap ; *T*—Testa ; *Vs*—Vascular supply.

24

25

26

Rc

27 End
T
cot
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Hr
vs

oi
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30

31

Dy.nb
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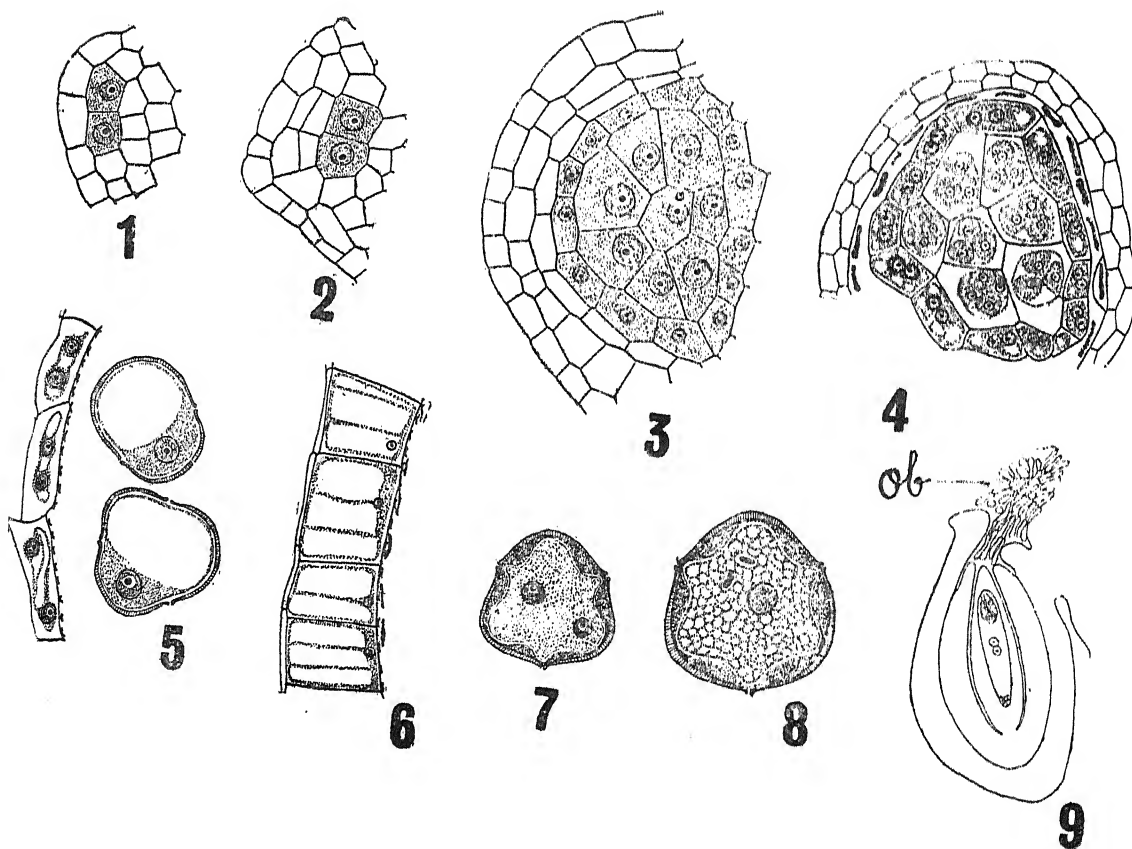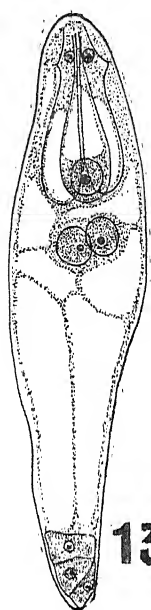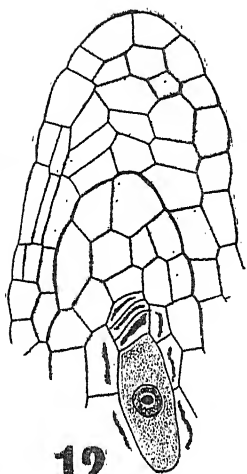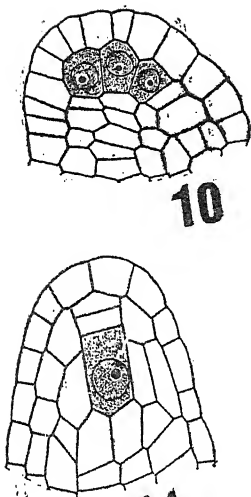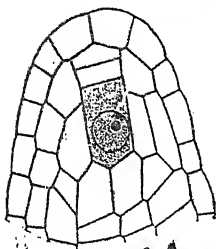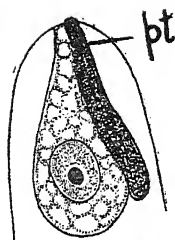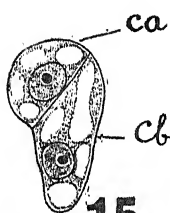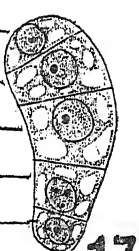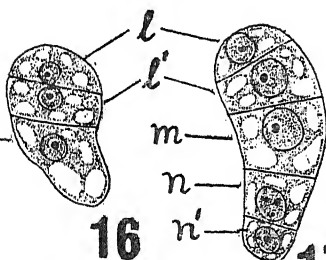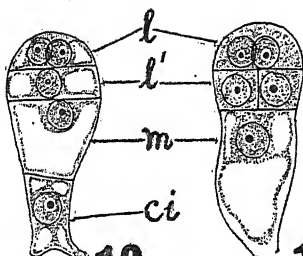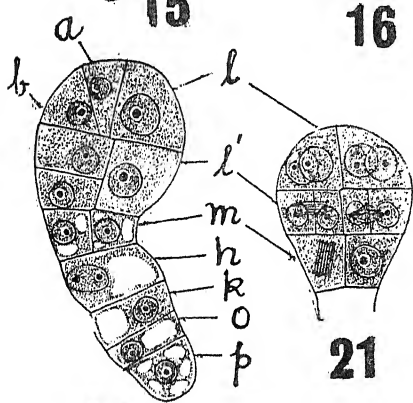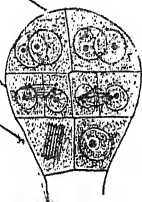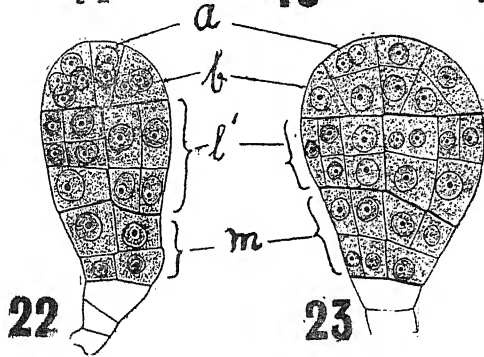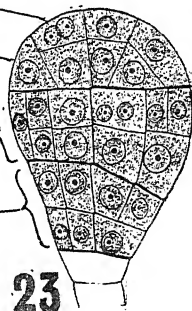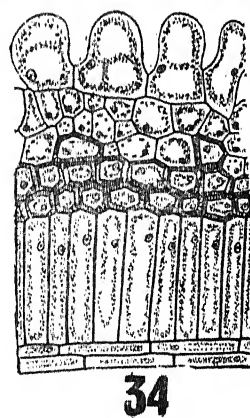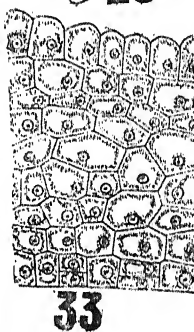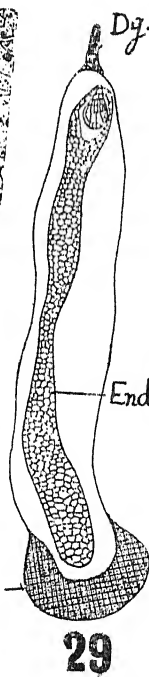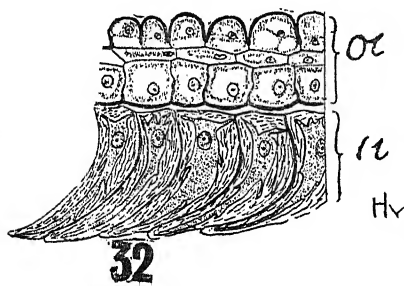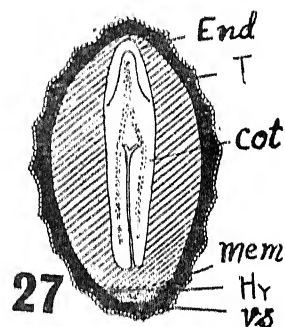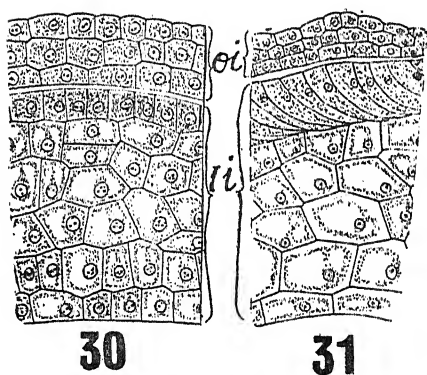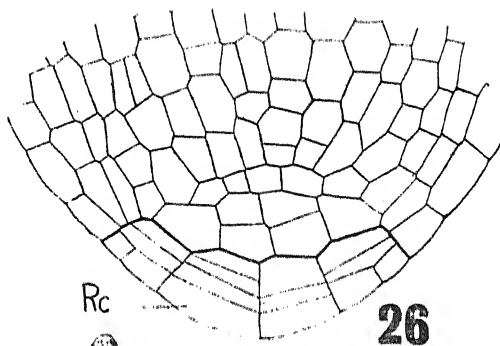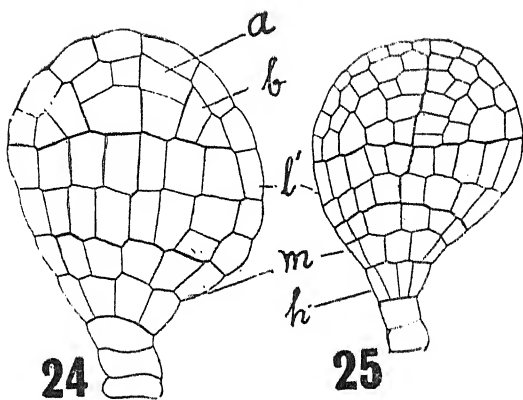
The sporogenous cells divide mitotically and form the pollen mother cells. These undergo the usual reduction division and form tetrads of microspores which are arranged in a tetrahedral or isobilateral manner (Fig. 4). Cytokinesis is effected by centripetal peripheral clevage furrows.

The young pollen grains are filled with dense cytoplasm. Later a vacuole arises and the centrally placed nucleus is pushed towards the periphery (Fig. 5) where it divides to form a generative cell and a tube cell (Fig. 7); their separating wall is ephemeral. The generative cell soon divides to form two male cells and the pollen grains are shed at the 3–celled stage (Fig. 8). The pollen grains are spheriodal and tricolpate with exine differentiated into sexine and nexine. The former is striated as seen in section (Figs. 7, 8). The nexine between the two colpi is thickened longitudinally to form two prominent ridges parallel to the polar axis which in transverse section presents a lenticular appearance (Fig. 8). The intine is a thin membrane

Structure of Ovule

The Euphorbiaceae are characterized by tricarpellary, trilocular, syncarpous, superior ovary. Each loculus has a pendulous ovule borne on an axile placenta. The ovules are anatropous, bitegminal and crassinucellar. The micropyle is formed by both the integuments. The nucellus is free from the inner integument up to the base and the nucellar tip does not protrude beyond the endostome (Fig. 9) as in *Ricinus communis* (Singh, 1954), *Putranjiva roxburghii*, *Trewia mudiflora* (Banerji and Dutt, 1944) and *Euphorbia dracunculoides* (Mukherjee, 1961).

The obturator arises as an outgrowth of the placenta and consists of loosely elongated, vacuolated finger-shaped cells. It enters the wide micropyle and reaches the tip of the nucellus (Fig. 9).

Megasporogenesis and Female Gametophyte

The hypodermal archesporium consists of two or three cells (Fig. 10). However, only one develops further forming a megaspore mother cell, after cutting a parietal cell (Fig. 11). The parietal cell as well as the nucellar epidermis divide to form the primary and secondary parietal tissues respectively (Fig. 12). The megaspore mother cell divides and forms the linear tetrad of megaspores of which the lowermost enlarges and develops further while the rest degenerate (Fig. 12). The degeneration of the other three megaspores starts from below upwards. The nucleus of the fuctioning megaspore enlarges and undergoes three more divisions to form an eight nucleate embryo sac of the Polygonum type (Maheshwari, 1950). The mature embryo sac is spindle shaped. The synergids are hooked and the pear shaped egg lies between them. The polar nuclei meet very near the egg. The antipodal cells are arranged more or less in a linear manner (Fig. 13).

Entry of the pollen tube is porogamous. The pollen tube during its entry into the embryo sac destroys one or both the synergids (Fig. 14).

Endosperm

Soon after fertilization the primary endosperm nucleus divides repeatedly and forms a number of free nuclei. At the 2–celled stage of the embryo eight endosperm nuclei distributed in the cytoplasm are seen. After further free nuclear divisions it is seen that a number of them get aggregated at the chalazal end of the embryo sac (Fig. 28). Wall formation around the endosperm nuclei

commences when the embryo has attained the stage shown by figure 22. By centripetal growth a cellular endosperm is produced (Fig. 29). While a part of the endosperm is utilized by the developing embryo a major portion persists in the seed. Thus the seeds are endospermic, a feature characteristic of the Euphorbiaceae. The endosperm cells are multinucleate, and densely packed with starch grains.

Embryo

The fertilized egg enlarges and after a short period of rest divides transversely to form two unequal cells ca and cb (Fig. 15). Later, cell ca divides transversely into l and l' (Fig. 16). Soon a transverse division in cb forms cells m and ci (Fig. 18). These four cells from upward are designated l, l', m and ci. During further development cell ci divides transversely to form n and n' (Fig. 17). The first vertical wall is generally laid down in the tier l (Fig. 18), but occasionally it may be noticed in the tier l' (Fig. 19). As a result of these two vertical divisions in l and l', four cells disposed in two tiers of two cells each are formed (Figs. 19, 20).

By the time vertical divisions are completed in tiers l and l', cell m also divides longitudinally to form two juxtaposed cells (Fig. 20). At the same time cells n and n' divide transversely to form cells h, k, o and p (Fig. 20).

The destination of the various tiers are given below. The cells of the tier l give rise to the stem tip and the cotyledons. The cells of the tier l' form the part of the hypocotyledonary portion, while the other half of the hypocotyl is derived from cell m. The rest of the derivatives of cell m give rise to the root tip, while the root cap is organized by cell h. The remaining cells k, o and p constitute the suspensor. This is shown in the following scheme :
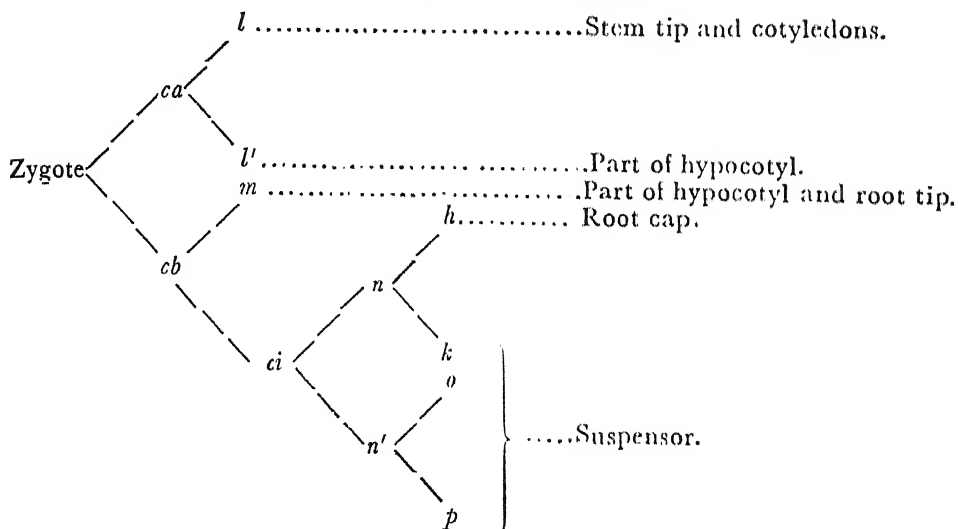
Thus the development of embryo in this species of *Euphorbia* agrees with the Chenopodiad type of Johansen (1950) and conforms to the same variation.

Cell l after the first vertical division forms two cells (Figs. 18, 19). These later divide obliquely to form cells a and b (Fig. 20). Cell a is quadrilateral in outline and adjacent to the axis (first vertical wall) while cell b is triangular in

shape. The tier l at this stage consists of four elements of a and four of b (Fig. 22). Next divisions in a and b are transverse forming the outer dermatogen and inner cells (Fig. 23). The inner cells by further transverse followed by longitudinal divisions form the stem tip and cotyledons (Figs. 24, 25). As already stated the penultimate tier l' divides first by a vertical wall to form two cells (Fig. 19). These cells divide by two more vertical walls and form four circumaxial and four outer peripheral cells (Fig. 21). At times the second division in the tier l' is transverse (Fig. 20). The four circumaxial cells derived from the tier l' by further divisions give rise to half of hypocotyl. The four outer peripheral cells form the dermatogen (Figs. 22, 24).

Cell m divides vertically to form two cells (Figs. 20, 21). The next division is transverse (Figs. 21, 22) resulting in two tiers. The upper tier of m divides by two more vertical walls and forms four circumaxial and four outer cells. The four circumaxial cells join with the four circumaxial cells of the tier l' and complete the hypocotyledonary region (Figs. 23, 24). The outer cells merge with the dermatogen of l and l'. The lower tier of m as a result of similar divisions, forms the four central cells which form the root tip and four outer cells which form dermatogen (Figs. 23, 24).

Cell h forms the root cap. It also divides vertically. In the two cells thus formed there is another vertical division to form an outer cell and inner cell (Fig. 25). The inner cell divides periclinally repeatedly to form the root cap while the outer cells form the dermatogen (Fig. 26). The remaining cells k, o and p form the biseriate suspensor. The table of recapitulation is given below :

I—First cell generation.

Proembryo of two cells disposed in two tiers.

$$ca = pco + pvt + \tfrac{1}{2}\,phy$$
$$cb = \tfrac{1}{2}\,phy + icc + iec + co + s$$

II—Second cell generation.

Proembryo of four cells disposed in four tiers.

$$l = pco + pvt$$
$$l' = \tfrac{1}{2}\,phy$$
$$m = \tfrac{1}{2}\,phy + icc + iec$$

III—Third cell generation.

Proembryo of eight cells disposed in five tiers.

$$l = pco + pvt$$
$$l' = \tfrac{1}{2}\,phy$$
$$m = \tfrac{1}{2}\,phy + icc + iec$$
$$n = co + s$$
$$n' = s \text{ (in part)}$$

IV—Fourth cell generation.

Proembryo of sixteen cells disposed in seven tiers.

$$l = pco + pvt$$
$$l' = \tfrac{1}{2}\,phy$$

[333]

$$\dot{m} = \tfrac{1}{2}\,phy + icc + icc$$
$$h = co$$
$$\left.\begin{array}{c} k \\ o \\ p \end{array}\right\} = s$$

Mature Embryo

The mature embryo is straight and dicotyledonous. It is surrounded by the endosperm with more of this tissue along the lateral sides and three to four layers above the root cap (Fig. 27). There are eight to ten layers of this tissue above the tips of the cotyledons. In the mature embryo the three histogenic layers are clearly demarcated. The root cap consists of fifteen to sixteen layers of cells. The periblem and plerome show nine to ten layers and eleven to twelve layers of cells respectively. The cells of the mature embryo are densely packed with starch grains. In the hypocotyl and cotyledons coenocytic laticiferous elements are noticed.

Hypostase

During post-fertilization, certain changes take place in the chalazal part of the nucellus. The cells of this region get regularly arranged, filled with dense cytoplasm and take a deep stain. They multiply and finally form a saucer-shaped hypostase, a structure also met with in other members of Euphorbiaceae (Landes, 1946 ; Gopinath and Gopalkrishnan, 1949 ; Kajale, 1954 ; Mukherjee, 1961 ; Nair, 1962). The hypostase is separated from the endosperm by a thin membrane of the embryo sac (Fig. 27). The vascular supply of the ovule terminates below the hypostase which persists in the mature seed as in *Euphobia hirta* (Kajale, 1954).

Seed coat

Both the integuments take part in the formation of seed coat as in other members of the family. The outer integument usually consists of three layers of cells (Fig. 30), but is multilayered at the micropylar region. The inner integument on the other hand consists of seven to eight layers of cells (Fig. 30) throughout its length ; at the micropylar end, however, it becomes thin and consists of only two to three layers. As development proceeds certain histological changes are noticed in the cells of the integuments. At the mature embryo sac stage the outer epidermal cells of the inner integument are filled with tanin and stain deeply when compared with other layers whose cells are vacuolated (Fig. 30). During further development this layer enlarges radially and the cells are obliquely arranged (Fig. 31). In the mature seed it forms the brittle stony layer of the tegmen (Fig. 32). The falcate cells of this layer are thick walled and show numerous pit canals as in *Acalypha rhomboidea* (Landes, 1946), *A. indica* (Johri and Kapil, 1953), *Euphorbia geniculata* (Singh, 1959) and *E. dracunculoides* (Mukherjee, 1961). The remaining layers of this integument degenerate (Fig. 32).

The three layers of the outer integument persist to form the testa (Figs. 30, 31, 32). The inner epidermal cells enlarge and their tengential and radial walls become thickened as in *Euphorbia dracunculoides* (Mukherjee, 1961). The middle layer becomes stretched. The outer epidermal cells become dome-shaped and their tangential walls are thickened making the seeds slightly warty (Fig. 32).

Pericarp

The ovary wall at the embryo sac stage, consists of eight to nine layers of cells (Fig. 33). The inner epidermal cells divide periclinally and become two layered (Figs. 33, 34). Later, these get tangentially elongated and thick-walled. The inner hypodermal cells become radially elongated and thick-walled (Fig. 34). Two or three layers of cells next to this become strongly sclerosed (Fig 34) as in *Euphorbia dracunculoides* (Mukherjee, 1961). These are next followed along by two to three layers of thin walled parenchymatous cells. The outer epidermal cells to start with, are rectangular, soon their free ends become bluntly papillose (Fig. 34).

Summary and Discussion

The male archesporium is multicellular and hypodermal as seen in *Euphorbia hypericifolia* and *E. dracunculoides* (Mukherjee, 1957, 1961). The anther wall is four layered. The layer below the epidermis develops into the fibrous endothecium. The tapetum, in conformity with most of the Euphorbiaceae, is of the secretory type. In *Acalypha indica* (Johri and Kapil, 1953), however, it has been reported to form a periplasmodium. The dehiscence of anther is by longtitudinal slit as seen in *Euphorbia microphylla* (Jain, 1956), *E. hypericifolia*, *E. dracunculoides* (Mukherjee, 1957, 1961) and species of *Phyllanthus* (Mukherjee and Padhye, 1964). Pollen grains are 3-celled at anthesis. They are tricolpate and the exine is differentiated into sexine and nexine as in *Euphorbia dracunculoides* (Mukherjee, 1961).

The ovules are anatropous, crassinucellar and bitegminal as in several other members of the family. In *Breynia patens* (Thathachar, 1963) they are orthotropous. The nucellus does not come out of the micropyle as in *Euphorbia dracunculoides* (Mukherjee, 1961), *Ricinus communis* (Singh, 1954), *Trewia nudiflora*, *Putranjiva roxburghii* (Banerji and Dutt, 1944), *Acalypha fallax* (Banerji, 1949) and *A. brachystachya* (Kapil, 1960) etc. The obturator here consists of thin walled elongated cells and is of loose type.

The female archesporium is multicellular. The development of female gametophyte is of Polygonum type. The genus *Euphorbia* shows as many as four types of embryo sac development. Majority of the species conform to Polygonum type. *Euphorbia mauritanica* (Ventura, 1933), *E. amygdaloides*, *E. characias* and *E. lagascae* (D'Amato, 1939) conform to bisporic type. Sharma (1955) has reported Adoxa type of embryo sac development in *Euphorbia pulcherrima* but his observations have been doubted by Kapil (1961). The only species of *Euphorbia* which conforms to Fritillaria type of development is *Euphorbia dulcis* (Caesca, 1961; Kapil, 1961).

Fertilization is porogamous. The primary endosperm nucleus is triploid in this species. It is 5-ploid in *Acalypha australis*, *A. brachystachya* and *A. tricolour*; 7 to 10-ploid in *A. indica* and *A. fallax*; and 8 or 9-ploid in *A. ciliata* (*see*, Kapil, 1960). The endosperm is free nuclear in the begining but eventually becomes cellular.

Most genera of Euphorbiaceae show the presence of hypostase. In the species of *Euphorbia* it develops during post fertilization stages (*see*, Kajale, 1954; Mukherjee, 1957).

The embryo development follows three main types. The Scabiosa variation of the Piperad type is seen in *Euphorbia rothiana* (Shrivastava, 1952). The Onagrad

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type shows three variation. The Lotus variation is met with in *Acalypha lanceolata* (Thathachar, 1952), *A. indica* (Johri and Kapil, 1953) and *A. ciliata* (Mukherjee, 1964). The *Euphorbia* variation is seen to occur in number of plants *viz.*, *Euphorbia hirta* (Kajale, 1954), *E. hypericifolia* (Mukherjee, 1957), *Acalypha brachystachya* (Kapil, 1960) etc. The Onagrad variation is met with only in *Acalypha malabarica* (Mukherjee, 1964). The Linum variation of the Solanad type is reported in the species of *Phyllanthus* (Mukherjee and Padhye, 1964).

A new type of embryo development for the family is added with the investigation of this species where it conforms to the Chenopodiad variation of the same type.

The seed coat develops from both the integuments. The histology and structure of pericarp is very much similar to that of *Euphorbia dracunculoides* (Mukherjee, 1961).

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NEEM SEED CAKE AS A SOURCE OF PEST CONTROL CHEMICAL
III—REPELLENCY AGAINST LOCUSTS

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Introduction

The desert locusts have long been known to be omnivorous feeders on almost all types of vegetation. Under certain conditions, they eat such substances as sheep wool and even practise cannibalism. But *neem* trees are the only plants that are not attacked by locusts. Volkousky (1939) noted that Pursian lilac and *Melia azadirachta* were absolutely avoided. In India, Roonwal (1938) observed that *ak* (*Calatropis procera*) and *neem* (*Azadirachta indica*) leaves were absolutely refused by locusts even upto death. The repulsiveness of *neem* and *ak* is confirmed by Hussain *et al.* (1949) and Roonwal (1953). Lal (1951), however, stated that adult locusts in swarm, once settled on some *neem* and other trees in Kanpur city and the locusts nimbled at the *neem* leaves, though the entire leaves were not eaten. Even during recent invasion by locusts at Indian Agricultural Research Institute, New Delhi, farm, no *neem* trees were found to be attacked by locust swarm (Sinha, 1962). Pradhan *et al.* (1962) observed that plants sprayed with *neem* kernel suspension were left alone by locusts which, however, had a bite at plants sprayed with refined *neem* products. Untreated plants were practically denuded by the locusts. These authors while using different products of *neem* have recorded the efficacy of some of these products as locust repellent (1963).

Preliminary trials were conducted in this laboratory to study the repellent properties of different fractions of *neem* seed cake. These experiments gave varying degree of repellency of the different fractions. But, alcohol extract of the cake gave encouraging results. Detailed experiments were, therefore, carried out by extracting the *neem* seed cake with alcohol under different conditions and the alcohol extractives thus obtained were tested as repellent against locusts.

Neem seed cake, as obtained from Hartcourt Butler Technological, Institute, Kanpur, was extracted with water, petroleum ether, normal hexane, alcohol under cold condition (16°C), at room temperature (25–30°C) and with hot alcohol under soxhlet. The extractives thus obtained were used as locust repellent.

Experimental Findings and Discussion

The weight of residual cake and extractives are given below :

	Wt. of extract %	Nature of extract	Sulphur %
1. Alcohol extract (25–30°C) after extraction with P. E.	7·5	Dark brownish viscous liquid with strong odour	1·32
2. Alcohol extract in cold room (16°C)	3·5	do	1·36
3. Hot alcohol extract (after 1)	4·5	do	0·627

The *neem* seed cake was first extracted with petroleum ether and subsequently extracted with alcohol at room temperature (25–30°C). The residual cake after processing as above still contained some bitter and odoriferous substances as observed by taste on tongue. It was further extracted with hot alcohol under soxhlet and was found to contain 4·5% of alcohol soluble material.

Another portion of the cake after extraction with petroleum ether was subjected to cold alcohol extraction (16°C) to study the effect of lower temperature on repellent properties of the extract. Thus, the following extracts were taken for their repellent studies.

1. Alcohol extract as obtained at room temperature.
2. Cold alcohol extract (16°C).
3. Hot alcohol extract (after 1).

The alcohol extract (at room temperature), the cold alcohol extract (16°C) and hot alcohol extract were prepared as emulsions using Triton × 100 as emulsifier (0·5) percent. The leaves of the maize were cut into $2'' \times 1''$ size and different concentrations of the above samples were applied on both sides of the leaves. The treated leaves were introduced in tubes marked with the same concentrations. The locusts were allowed to starve for 24 hours and observations recorded. The feeding percentage is given in the following tables

TABLE I

Repellency test of alcohol extract as obtained at room temperature (After P. E. extraction)

% Concentration	Percentage feeding of treated leaves REPLICATIONS										% Average Feeding
	1	2	3	4	5	6	7	8	9	10	
0·50	0·00	0·00	0·00	00·0	0·00	0·00	0·00	0·00	0·00	9·30	0·93
0·25	0·00	0·00	0·00	12·60	0·00	6·00	8·60	0·00	0·00	0·00	2·75
0·10	95·00	86·60	16·00	0·00	56·00	30·60	80·00	61·60	94·00	93·30	60·71
0·05	70·00	100·00	93·30	86·60	83·30	80·60	21·30	69·50	60·00	73·80	73·78
Control	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE II

Repellency test with cold alcohol extract (16°C)

% Concentration	Percentage feeding of treated leaves					% Average Feeding
	1	2	3	4	5	
0·50	0·00	0·00	0·00	0·00	0·00	0·00
0·25	0·00	0·00	0·00	10·00	7·50	3·50
0·10	80·00	70·00	0·00	50·00	40·00	48·00
0·05	90·00	80·00	100·00	85·00	70·00	86·00
Control	100·00	100·00	100·00	100·00	100·00	100·00

Repellency test with hot alcohol extract (After alcohol extraction at room temperature). The preliminary test showed this to be less effective and so higher concentration of the samples were prepared

%Concentration	Percentage feeding of treated leaves					%Average Feeding
	1	2	3	4	5	
2·00	0·00	0·00	0·00	0·00	0·00	0·00
1·75	0·00	0·00	0·00	0·00	0·00	0·00
1·50	33·30	41·30	25·00	41·60	25·00	33·30
1·25	68·30	66·60	61·60	50·00	70·00	63·30
1·00	83·30	70·00	66·60	68·60	73·30	72·30
Control	100·00	100·00	100·00	100·00	100·00	100·00

Discussion

The alcohol extract as obtained at room temperature is quite potent and effective at 0·5% concentration and percentage feeding by locusts was practically nil at 0·5% and 0·25% concentrations while at 0·1 and 0·05 concentration the average feeding was 60·71% and 73·78% respectively as against 100% feeding in the control. The percentage feeding with cold alcohol extract was practically nil at 0·5% and 0·25% concentration. The average feeding at 0·1% and 0·05% concentration were 48·0% and 86·0% respectively as against 100% in control. Hence, this fraction is as effective as alcohol extract at room temperature as a repellent against locusts. Thus, extraction at lower temperature with comparatively low yield (3·5%) did not offer any particular advantage over extraction at room temperature. The hot alcohol extract (after extraction at room temperature) was effective at much higher concentration as compared to first two extracts. It was effective at 2·0% and 1·75% concentrations where the feeding was nil. The average feeding at 1·5%, 1·25% and 1·0% concentrations of the material was 33·3%, 63·3% and 72·3% respectively as against 100% feeding in the control. This suggests that biologically active material left after percolation with alcohol at the room temperature gets inactivated at higher temperature during hot aclonol extraction. It also indicates that most of the active substances of *neem* seed cake get extracted with alcohol at room temperature.

Sulphur content of hot alcohol extract was 0·72% (Sinha, 1963) and sulphur content of alcohol extract at room temperature was 1·32%. This might be due to removal of fatty matter (about 50%) which did not contain any sulphur. Subsequently, sulphur content of alcohol extract (room temperature) which was devoid of fatty matter has considerably increased on percentage basis. Thus, by first treating the cake with petroleum ether and subsequently extracting it with alcohol, a material was obtained which contained 1·32% sulphur and was biologically active. The higher repellency of this fraction was attributed to higher percentage of sulphur containing compounds. Hence, in an attempt to get sulphur bearing material in more concentrated form cold alcohol extract (16 C) was prepared. It was 3·5% in yield and contained 1·36% sulphur. This leads to the conclusion that percolation at lower temperature did not significantly improve concentration of sulphur in the extract.

Field tests during locusts invasion

When the laboratory studies were under way, a locust invasion took place in the first week of August, 1962, which provided an opportunity for testing the above observations on field scale.

10% of emulsifier concentrate of alcohol extract was prepared. This was diluted with water at 1·0% level and emulsion applied to field crops, such as, maize, *jowar*, *kalai* and ornamentals (roses and bougainvillea), This formulation acted as positive repellent against locusts in the treated areas and gave protective coverage and protection to the crops against the destructions caused by locusts invasion as compared to the untreated crops in the same area. No phytotoxicity was observed on any of the treated crops and ornamentals.

Summary

The desert locusts have long been known to be omnivorous feeders on almost all types of vegetation. But *neem* trees are the only plants that are not attacked by locusts. *Neem* leaves are used by some people as a pot herb and an insect repellent ; they are commonly kept in woolen clothes and books to protect them against insect attack.

Volkousky (1939) noted that *Pursian lilac* and *Melia azadirachta* were absolutely avoided by locusts. In India, Roonwal (1939) observed that *ak* (*Calotropis procera*) and *neem* (*Azadirachta indica*) leaves were absolutely refused by locusts even upto death.

The present communication is in continuity of the previous work carried out by Sinha and Gulati (1963) and refers to the activity of different fractions of *neem* seed cake. Some of the fractions of the *neem* seed cake have been found to be good locusts repellent.

The *neem* seed cake was extracted with water, petroleum ether, normal hexane, alcohol under cold condition (16°C), at room temperature (25°–30°C) and with hot alcohol under soxhlet. The extractives thus obtained were used as locust repellent.

The alcohol extract as obtained at room temperature have been found to be quite potent at 0·25% concentration and locust feeding was practically nil at 0·5% and 0·25% concentrations, as against 100% feeding in the control. The cold alcohol extract was also found to be equally effective against locusts. The hot alcohol extract was effective at much higher concentration as compared to the first two extracts. This suggests that biologically active material left after percolation with alcohol at room temperature gets inactivated at higher temperature during hot alcohol extraction. It also suggests that most of the active substances of *neem* seed cake get extracted with alcohol at room temperature.

Thus, by first treating the cake with petroleum ether and subsequently extracting it with alcohol a material was obtained which contained 1·32% sulphur and was biologically active. The higher repellency of these fractions was attributed to higher percentage of sulphur containing compounds. In an attempt to get sulphur bearing material in a more concentrated form, cold alcohol extract (16°C) was prepared. It was 3·5% in yield and contained 1·36% sulphur. Thus percolation at lower temperature did not significantly improve concentration of sulphur bearing compounds in the extract.

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1·0% emulsion of alcohol extract was applied to field crops (during locust invasion in August, 1962) such as maize, *jowar*, *kalai* and ornamentals (roses and bougainvillea). The emulsion of alcohol extract acted as positive repellent against locusts in the treated areas and gave protection to the treated crops as compared to the untreated crops in the same area. No phytotoxicity was observed on any one of the treated crops and ornamentals.

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RHIZOSPHERE MYCOFLORA OF CLUSTERBEANS (*CYAMOPSIS PSORALIOIDES* DC.) IN RELATION TO ROOT EXUDATES

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Introduction

The role of soil microflora in the biological complex of soil is well known and is of still greater interest in the rhizosphere (Hiltner 1904), the region under the influence of roots. The roots exercise an influence on micro-organisms, which in turn affect the growth of the plant both in health and disease (Starkey 1929). The microflora around the roots play an important part especially in root diseases. Clusterbeans are subject to serious root-rot disease caused by *Sclerotium rolfsii* Sacc. The soil capable of causing a severe root-rot condition may be variously modified by rhizosphere mycoflora of clusterbeans at various stages of root development. The number and type of organisms in the root zone are influenced by several factors such as nature and age of the plant, soil factors, treatment of soil, and nature of root exudates (Bhuvaneswari and Sulochana 1955 ; Lochhead, Katznelson and Timonin 1948). Waksman (1924) has particularly emphasized the role of C/N ratio on the soil microflora. The root exudates are also known to have a profound influence on the rhizosphere fungi (Katznelson, Ruatt and Payne 1954 ; Sulochana, 1958 and Timonin 1941). Keeping this in view, the qualitative and quantitative changes in the rhizosphere mycoflora of clusterbeans was studied during *kharif** 1961 in particular relation to C/N ratio of soil and the root exudates.

Materials and Methods

The analysis of mycoflora and C/N ratio of the intitial soil was compared with that of the rhizosphere of clusterbeans at intervals of thirty days until harvest. The experiments were arranged in four series, each series consisting of 12 replicate pots. In the first series no sowing was done and the initial soil was left as such. In the second, third and fourth series, 3 seeds of clusterbeans. were sown in each 9″ pot and later thinned to one. The observations were made at the end of thirty days' growth in the second series, sixty days' growth in the third series and ninety days' growth (harvest) in the fourth series. The root exudates were tested chromatographically for amino acids as these are known to influence sporulation. The effect of exudates on the percentage spore germination of the fungi, isolated from the initial soil, was studied to explain the type of mycoflora found under the influence of roots of the growing crop.

The fungi occurring in the initial soil and soil adhering to the roots were isolated following 'dilution plate method' (Waksman 1927) on Martin's Rose Bengal medium (Allen 1951). Colony counts were made adopting standard methods and total fungal population per mgm. of soil was calculated. The rhizoplane fungi were isolated following the method adopted by Agnihothrudu (1953).

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*Growing period from July to October.

The organic carbon content was determined by Walkley and Black's rapid titration method and total nitrogen estimated by Kjeldahl's method (Piper 1952). Root exudates were obtained by the technique evolved by Buxton (1957). The germination percentage of spores of the fungi isolated from the initial soil was determined by 'hanging drop method'. Amino acids of the root exudates were detected by 'descending chromatography' (Block, Durrum and Zweig 1955). The root exudates were spotted on Whatman filter paper No. 1 along with known amino acids. Butanol—acetic acid—water (4 : 1 : 5) was used as solvent and 0·3% ninhydrin solution as developer. The Rf values of the spots of root exudates were calculated and compared with the Rf values of the spots of known amino acids.

Results and Discussion

The results, as shown in Table I and Fig. 1, indicate that the initial soil has the largest number of fungal species. There are 24 fungi in the initial soil, 15 in the rhizosphere of thirty days, 14 in the rhizosphere of sixty days and 16 in the rhizosphere at harvest. This is in agreement with the work of Agnihothrudu (1953), who observed that in leguminous plants fungal types in the rhizosphere in general continue to decrease up to the time of flowering followed by an increase. But looking at the total number of colonies, the fungal population is on the increase from 188 colonies per mgm. in initial soil to 365 in the rhizosphere at harvest. This is in conformity with the observations of previous workers (Lochhead, Katznelson and Timonin 1948 ; Lochhead 1959 and Starkey 1929).

All the 24 fungi isolated from the initial soil do not continue to exist in the rhizosphere. After thirty days the rhizosphere has only 15 fungi among which 12 are the same as in the initial soil while 3 viz., Aspergillus japonicus, Penicillium sp. (i) and Fusarium semitectum are new colonizers. In the rhizosphere of sixty days, 7 species viz., Trichoderma koningi, Aspergillus japonicus, Cladosporium sphaerospermum, Curvularia lunata, Fusarium semitectum and unidentified spp. (i and ii) are new additions to those of the initial soil while the rest are the same. The mycoflora in this rhizosphere as compared to the rhizosphere of thirty days and the initial soil shows an addition of 5 species viz., Trichoderma koningi, Cladosporium sphaerospermum, Curvularia lunata and unidentified spp. (i and ii). The species of the initial soil, which were not found in the rhizosphere of thirty days are also absent mostly from the rhizosphere of sixty days. Sixteen species of fungi were isolated from the rhizosphere at harvest. Out of these Mucor hiemalis and Fusarium sp. (i) are new appearances as compared to those of the initial soil and previous rhizospheres. Five species, viz., Trichoderma koningi, Cladosporium sphaerospermum, Curvularia lunata and unidentified spp. (i and ii) are the same as present in the sixty days' rhizosphere. Fusarium semitectum is common in all the 3 rhizospheres, the remaining 8 species are those present in the initial soil also. Most of the fungi of the initial soil that had disappeared from the rhizospheres of thirty and sixty days continued to be absent from the rhizosphere at harvest.

The population (total number of colonies) as calculated per mgm. of soil indicated a trend on the increase from the initial soil to the rhizosphere. The number of colonies in the initial soil is 188, while in the rhizosphere it rose to 223, 237 and 335 after 30, 60 and 90 days respectively. This shows that there is greater increase in population after flowering but not so much before flowering. As pointed out earlier, the population of the mycoflora is known to be affected by the root exudates. A study of this relationship is presented in Table II. Only amino acids have been considered as the factor in the root exudates in these experiments. Seven amino acids, Glycine, Glutamic acid, dl-Methionine, dl-Tryptophane, dl-Valine, l-Arginine and an unknown acid

were detected in the root exudates. The changes in the population of fungi are likely to be associated with the percentage germination of these organisms. As indicated in the table the percentage germination of spores in root exudates decreases in the case of *Choanephora cucurbitarum* (44·30–39·50), *Aspergillus candidus* (13·80–10·51), *A. foetidus* (17·60–3·46), *A. restrictus* (14·84–10·01), *Penicillium funiculosum* (34·50–30·26), *Alternaria tenuis* (59·90–43·70), *Fusarium orthoceras* (51·20–29·01) and *Fusarium oxysporum* (82·60–81·91). On the other hand percentage germination increases in *Rhizopus arrhizus* (17·93–32·47), *Aspergillus fumigatus* (49·19–66·00), *A. nidulans* (17·40–39·16), *A. sydowi* (60·30–63·19), *A. tamarii* (28·21–29·50), *A. versicolor* (25 30–40·37), *Penicillium oxalicum* (11·60–45·45), *P. lilacinum* (27·50–71·27), *P. steckii* (38·50–53·85), *Phoma hibernica* (5·43–9·94), *Helminthosporium australiense* (31·53–59·55) and *H. rostratum* (6·01–33·65). The observations further reveal that those species of fungi in which the germination percentage is increased in the root exudates are mostly present in the rhizosphere at harvest. These species are : *Rhizopus arrhizus*, *Aspergillus fumigatus*, *A. sydowi*, *A. tamarii*, *Penicillium lilacinum* and *Helminthosporium australiense* ; while those which show a reduced germination percentage are mostly absent from the rhizosphere viz., *Choanephora cucurbitarum*, *Aspergillus candidus*, *Penicillium funiculosum*, *Alternaria tenuis*, *Fusarium orthoceras* and *Fusarium oxysporum*. The pattern of root exudates is thus specific indicating a trend that those species of the initial mycoflora in which the germination percentage of spores is increased are mostly present in the rhizosphere, while the others disappear.

TABLE I

A comparative study of Mycoflora and C/N ratio of initial soil and the rhizospheres of clusterbeans

	Initial soil	Rhizosphere after 30 days		Rihzosphere after 60 days		Rihzosphere after 90 days	
C/N ratio	4·890	4·170		8·429		15·557	
Mycoflora	No. of colo. in 0·1 mgm. of soil	No. of colo. in 0·1 mgm. of soil	Rhizo-plane fungi	No. of colo. in 0·1 mgm. of soil	Rhizo-plane fungi	No. of colo. in 0·1 mgm. of soil	Rihzo-plane fungi
1. *Rhizopus arrhizus* Fischer	0·22	—	—	1·77	—	0·11	—
2. *Mucor hiemalis* Wehmer	—	—	—	—	—	0·88	—
3. *Choanephora cucurbitarum* (Berk. and Rav.) Thaxter	0·11	—	—	—	—	—	—
4. *Phoma hibernica* Grimes, O'Conner and Cummins	0·11	—	—	—	—	—	—
5. *Trichoderma koningi* Oudem	—	—	—	0·66	—	1·10	—
6. *Aspergillus candidus* Link	4·30	0·56	—	—	—	—	—
7. *A. foetidus* Nakjaba	0·44	0·88	+	1·30	+	5·40	+
8. *A. fumigatus* Fres.	0·44	0·66	—	3·80	+	7·10	—
9. *A. japonicus* Saito	—	—	+	—	+	—	—
10. *A. nidulans* (Eidam) Winter	0·11	—	—	—	—	2 30	—
11. *A. restrictus* Smith	0·44	0·22	—	—	—		

Mycoflora	Initial (C/N 4·890) No. of colo. in 0·1 mgm. of soil	Rhizosphere after 30 days (C/N 4·170) No. of colo. in 0·1 mgm. of soil	Rhizosphere after 30 days Rhizoplane fungi	Rihzosphere after 60 days (C/N 8·429) No. of colo in 1 mgm. of soil	Rihzosphere after 60 days Rhizoplane fungi	Rihzosphere after 90 days (C/N 15·557) No. of colo. in 0·1 mgm. of soil	Rihzosphere after 90 days Rihzoplane fungi
12. *A. sydowi* Thom and Church	1·88	8·40	+	6·50	+	8·40	–
13. *A. tamarii* Kita	0·88	0·77	–	0·44	–	0·11	–
14. *A. terreus* Thom	0·33	0·11	–	–	–	–	–
15. *A. versicolor* Tiraboschi	0·11	–	–	–	–	–	–
16. *Penicillium oxalicum* Thom	0·11	–	–	–	–	–	–
17. *P. lilacinum* Thom	4·66	6·00	+	3·50	–	0·88	–
18. *P. steckii* Zaleski	1·55	1·55	–	–	–	–	–
19. *P. funiculosum* Thom	0·44	0·55	–	–	–	–	–
20. *P.* sp. (1)	–	0·11	–	–	–	–	–
21. *Acrostalagmus cinnabarinus* Oudemans	0·11	–	–	–	–	–	–
22. *Helminthosporium australiense* Bugnicourt	0·22	0 11	–	1·30	–	3·00	–
23. *H. rostratum* Dreschl.	0·66	–	–	–	–	–	–
24. *Cladosporium sphaerospermum* Penzig	–	–	–	0·55	–	1·30	–
25. *Curvularia lunata* Boedijn	–	–	–	0·33	–	0·44	–
26. *Alternaria tenuis* Nees	0·11	0·11	–	–	–	–	–
27. *Fusarium orthoceras* Appel and Wollenweber	0·11	–	–	–	–	–	–
28. *F. oxysporum* Schlechtendahl	0·11	–	–	–	–	–	–
29. *F. solani* Appel and Wollenweber	0·22	–	–	–	–	–	–
30. *F. semitectum* Berkeley and Ravenel	–	2·10	+	1·30	+	0·88	+
31. *F.* sp. (*i*)	–	–	–	–	–	1·60	–
32. *Mycelia sterili* sp.	0 11	–	–	–	–	–	–
33. Unidentified sp. (*i*)	–	–	–	0·88	+	1 66	+
34. Unidentified sp. (*ii*)	–	–	–	0·88	+	1·60	+
Total number of species	24	15		14		16	
Total population (Number of colonies per mgm. of soil)	188	223		237		335	

Colo = Colonies
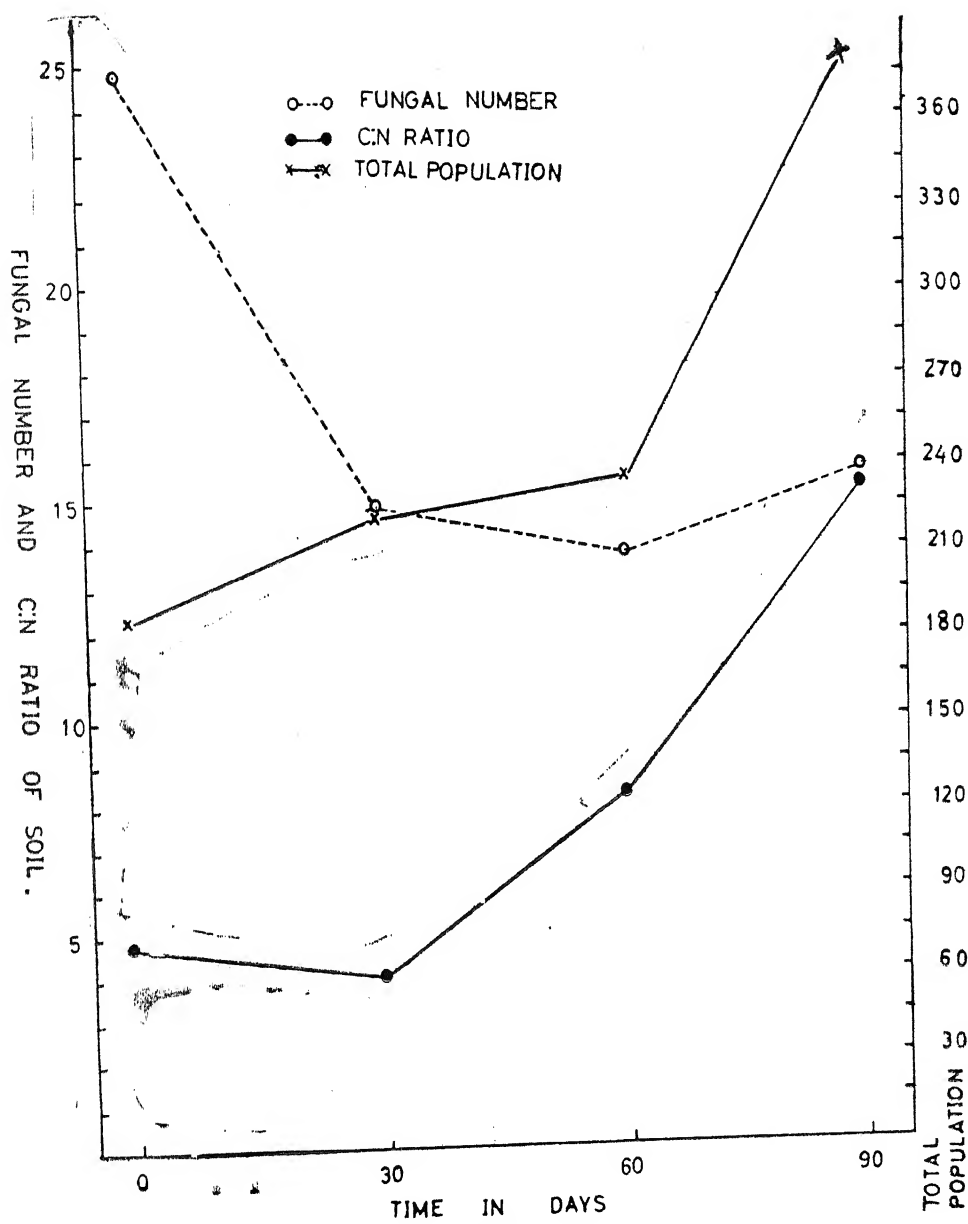
Rhizosphere mycoflora of clusterbeans in relation to root-exudates.

TABLE II

Percentage germination of spores of various sporulating soil fungi in root exudates of clusterbeans

Amino acids present in root exudates	Glycine (++·), Glutamic acid (+++), dl – Methionine (++), dl – Tryptophane (++), dl – Valine (++), 1 – Arginine (+) and Unknown acid (+)	
S. No. Species of fungi	In distilled water	In root exudates
1. *Rhizospus arrihizus* Fischer	17·93	32·47
2. *Choanephora cucurbitarum* (Berk. and Rav.) Thaxter	44·30	39 50
3. *Aspergillus candidus* Link	13·80	10·51
4. *A. foetidus* Nakjaba	17·60	3·46
5. *A. fumigatus* Fres.	49·19	66·00
6. *A. nidulans* (Eidum) Winter	17·40	39·16
7. *A. restrictus* Smith	14·84	10·01
8. *A. sydowi* Thom. and Church	60·30	63·19
9. *A. tamarii* Kita	28 21	29·50
10. *A. versicolor* Tiraboschi	25·30	40·37
11. *Penicillum oxalicum* Thom	11·60	45·45
12. *P. lilacinum* Thom	27·50	71·27
13. *P. steckii* Zaleski	38·50	53·85
14. *P. funiculosum* Thom	34·50	30·26
15. *Phoma hibernica* Grimes, O'Conner and Cummins	5·43	9·94
16. *Helminthosporium australiense* Bugnicourt	31·53	59·55
17. *H. rostratum* Dreschl.	6·01	33·65
18. *Alternaria tenuis* Nees	51·90	43·70
19. *Fusarium orthoceras* Appel and Wollenweber	51·20	99·01
20. *F. oxysporum* Schlechtendahl	82·60	81·91

+, + +, and + + + show the increase in concentration of amino acids as shown by intensity of spots.

Waksman observed that the C/N ratio largely depends upon the activities of soil microorganisms. The increase in the activities of mycoflora at various age levels of the plant in the rhizosphere, as indicated by total population, can be correlated with the increase in C/N ratio. The C/N ratio determined for initial soil is 4·890 and 4·170 for the rhizosphere soil after thirty days' growth. This initial decrease is probably due to the liberation of amino acids and loss of carbon

due to absorption, of nutrients by the roots. The C/N ratio after sixty days'dna ninety days' growth is 8·429 and 15·557 respectively. This increase in C/N ratio is due to increase in carbon percentage and decrease in nitrogen as seen in the experiments. Increase in percentage of carbon can be explained as probably due to greater excretion of amino acids and decrease in nitrogen percentage due to continuous utilization of nutrients, which contain a part of nitrogenous substances by the plant and lesser liberation of amino acids in the rhizosphere as the plant becomes old. The decrease in number and concentration of amino acids has also been reported in older plants as compared to seedlings (Timonin 1941).

So the increase in number of colonies and reduction in the number of fungal species in the rhizosphere of *Cyamopsis psoralioides* is followed by an increase in C/N ratio. The root exudates consisting of various metabolites particularly the amino acids act as growth factors for the fungi and therefore those fungi are mostly recorded in the rhizosphere whose germinarion is stimulated in the root exudates.

Summary

An analysis of rhizosphere mycoflora of clusterbeans in relation to root exudates has been done. Twenty four species of fungi were isolated from the initial soil and 15, 14 and 16 from the rhizospheres after thirty, sixty and ninety days' growth respectively. The total fungal population increased from initial soil to the rhizosphere at the harvest time and this was found to correspond with the effect of root exudates on increase in germination percentage of fungus spores. The root exudates were shown to contain 7 amino acids. The C/N ratio of the rhizosphere soil was increased from 4·170–15·557. Thus the present study indicates that the composition of species and total fungal population in the rhizosphere is mostly governed by the roots and their secretions and excretions, the mycoflora in turn brings about the changes in C/N ratio of soil.

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A NOTE ON THE INSECTICIDAL PROPERTY OF *ANNONA SQUAMOSA* (ANNONACEAE)

By

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According to Gunther and Jeppson (1960) "With the few notable exceptions, the identities of the active plant constituents are unknown but their entomological performances have been noted and in some instances extensively explored. A number of organic compounds obtained from a majority of plant kingdom have been reported to be toxic to men, animals and insects. The well known organic substances like nicotine alkaloids, pyrethroids, rotenoid, camphor and terpentine are being used as an insecticides for a long time." It has been reported by Chopra *et al.* (1949) that out of numerous plant species of India about 74 plants are supposed to have insecticidal properties. Very little work has been done in India to confirm whether these plants have any possibility of producing any insecticide of potential value. The only systematic work has been done by Abrol and Chopra (1963) who have investigated some 40 plants and have classified these plants according to insecticidal values or toxicity.

The present study deals with insecticidal acitivity of the leaf extract in Ether of *Annona squamosa* on the Red pumpkin Beetle (*Aulacophora foveicollis*) a serious pest of cucurbits. Although the insecticidal properties of *Annona squamosa* seeds have been examined by Mukerjea and Ram Govind (1958), they have also reported that the Annona leaf is supposed to have some contact insecticidal property but did not investigate it.

Annona squamosa (Sharifa).—It grows wild as well as being cultivated throughout India. Leaf, root and seed all are supposed to show contact insecticidal action.

Methods and Observation

The leaves of *Annona squamosa* were collected from the local garden and dried in hot air oven at 59°C for 24 hrs. Oven dried leaves were powdered and

stored in a dry glass container. 10 gms. of leaf powder was extracted with 200 ml of Ether for 2 hours in a soxhlet apparatus. After complete extraction the Ether was distilled leaving 20 to 30 ml of ether extract in the extraction flask. This extract was transferred in a tared flask, which was again kept on the water bath for evaporating the remaining ether. The greenish viscous residue weighing 1·2538 gms thus obtained was diluted with 4 ml of acetone in order to facilitate its handling. To test the efficacy of the above extract the experiment was set up as follows :

Five petridishes of the same size were taken and in each of which 5 ml. of acetone was poured. To each of these petridishes different amount of the acetone diluted extract was added e.g. in petridish no. 1 – 0·1 ml. no. 2 – 0·2 ml., no. 3 – 0·3 ml and no. 4 – 0·4 ml. and no. 5 was kept as a control i.e. no extract was added. The petridishes were gently shaken so as to enable the extract to mix thoroughly with acetone of the petridish and to spread uniformly. All the petridishes together with control were kept for air drying. After the evaporation of acetone an uniform film of extract was left. In these petridishes suitable sized lantern glass were placed in such a way that the bottom end of the lantern glass fitted properly on the side walls of petridishes. To each of these petridishes 20 insects of same size were dropped from the top (open end) and then the upper end of the lantern glass was covered with small mesh thin cloth and was tied with rubber band. This was done in order to avoid the respiratory difficulties of the insect as well as to prevent them from escaping away. Mortality observations were made after keeping the insects with the extract for 24 hrs. Table below shows the result :

TABLE

Observations showing toxicity of Annona squamosa *leaf extract against* Aulacophora foveicollis *Red Pumpkin Beetle*

Serail Number	No. of insects in each replication	Vol. of extract used	Quantity of extract in gms	No. of replications	Condition of insects after 24 hours			Mortality percentage
					Living	Moribund	Dead	
1	20	0·4 ml	0·124	4	1·25	0·50	18·25	93·25 %
2	20	0·3 ml	0·093	4	1·25	2·50	16·25	93·25 %
3	20	0·2 ml	0·062	4	1·75	2·75	15·50	91·25 %
4	20	0·1 ml	0·031	4	4·25	4·50	11·25	78·75 %
5	20	Control	–	4	20	–		0%

Conclusion

It is quite evident from the above observation that the leaf extract of *Annona squamosa* is insecticidally active. There is no difference in mortality percentages at 0·3 ml and 0·4 ml concentration and has a minor difference between 0·2 ml and

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0·3 ml. So 0·2 ml (·062 gm) concentration proves to be economic in controlling the above mentioned pest. Further work on different parts of the plant is under investigation.

Summary

The present study deals with the insecticidal activity of the leaf extract of *Annona squamosa*. The insecticidal activity of the seeds of this plant was investigated by Mukerjea and Ram Govind (1958). They have reported that the leaves of this plant are likely to have some insecticidal property. In the present study the leaves were collected from local garden and then dried in a hot-air oven at 59°C for 24 hrs. The powdered leaves were extracted in ether. The extract was dried, weighed and then diluted in acetone for experimenting on insect. The results show that the leaf extract has a good contact insecticidal property *e.g.* 0·2 ml of this diluted extract containing about 0·062 gm of the dry extract gave a 91 % mortality on *Aulacophora foveicollis* F. Red pumpkin Beetle.

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NOTE ON THE GROWTH RATE OF ALIMENTARY CANAL IN
GALERUCELLA BRIMANICA "SINGHARA BEETLE"
(COLEOPTERA : CHRYSOMELIDAE)

By

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In the present study an effort has been made to study the rate of growth of the different parts of alimentary canal in relation to its body length.

The insect *Galerucella brimanica* was selected on account of two factors, firstly that it is abundantly available and has a short life cycle period and secondly that no work has so far been done on the alimentary canal of this insect. The alimentary canal of this insect has the usual division and usual structures excepting for some minor details.

Material and Technique

The insect and eggs were collected along with the host-plant (Singhara) from local tanks and reared in laboratory under normal laboratory conditions.

The insects of different stages were dissected under Binocular Sterioscopic Microscope in salt solution (0·75%) and complete alimentary canal was removed and spread on a slide, and measurements were noted under microscope.

Observations

The just hatched larva measures 1·193 mm. in length, while the alimentary canal measures 2·698 mm. Ratio between the total body length and that of alimentary canal was 1 : 2·2. The different structures e g. fore-gut, mid-gut and hind-gut measured 0·238 mm., 1·578 mm. and 0·822 mm. respectively. In the full grown first instar larva just before moulting the different structures of the alimentary canal showed an increase of 0·184 mm., 1·684 mm. and 0·368 mm. in fore-gut, mid-gut and hind-gut respectively. Where as the body length increased by 0·944 mm., the alimentary canal grew 2·172 mm. longer and thus still maintaining a ratio of 1 : 2·2. Though the different parts increased at different rate but the over all ratio still remained more or less the same.

In the second instar, the initial measurements just after moulting are at follows : Body length 2·165 mm., fore-gut 0·438 mm., mid-gut 3·444 mm., hind-gut 1·409 mm. and alimentary canal 5·292 mm. In this we find that ratio between body length and alimentary canal has increased to 1 : 2·4 and the measurements for the full grown second instar larva just before moulting were as follows : Fore-gut 0·583 mm., mid-gut 6·239 mm., hind-gut 2·282 mm., alimentary canal 9·104 mm. and body length 3·92 mm. Ratio between body length and alimentary canal shows a reduction, *i.e.* 1 : 2·3.

In the just moulted third instar larvae, we found the measurements as follows : Body length 3·570 mm., fore-gut 0·723 mm., mid-gut 5·96 mm., hind-gut

2·347 mm. and alimentary canal 9·03 mm. Ratio between body-length and aliment-ary canal 1 : 2·2. Where as the same measurements in a full grown larva 60 hours before pupation shows : Body length 4·988 mm., fore-gut 0·975 mm., mid-gut 8·941 mm., hind-gut 2·954 mm. and alimentary canal 12·614 mm. The ratio between body length and the alimentary canal 1 : 2·5 is at its maximum at this period and the larva shows the maximum development. After 60 hours *i.e.*, just before moulting for pupation the larva shrinks in size and the internal structure show a corresponding reduction in size the measurements are as follows : Body length 4·55 mm., fore-gut 0·555 mm., mid-gut 3·541 mm., hind-gut 1·871 mm. and alimentary canal 5·301 mm. the ratio between body length and alimentary canal now becomes 1 : 1·8.

Conclusion

From the above study we find that (*i*) there is no fixed rate of growth for the alimentary canal for this insect. (*ii*) The ratio between the rate of growth of body length and total alimentary canal though not fixed for all stages but varies little excepting for just before pupating, when the insects (larvae) shrink and prepare to moult for pupation. (*iii*) Similarily the rate of growth of the different structure shows that there is no fixed rate of growth.

From this study we find that the growth of the different parts in different instars are as follows :

TABLE I

Larval stage	Fore-gut mm.	Mid-gut mm.	Hind-gut mm.	Alimentry canal mm.	Body-length mm.
Just hatched—First instar	0·238	1·578	0·882	2·698	1·193
First instar	0·2	1·866	0·527	2·594	0·972
Second instar	0·285	2·516	0·938	3·738	1·405
Third instar	0·252	2·981	0·607	3·584	1·418

Table II shows growth rate/hour in mm. of different parts in different instars.

TABLE II

Larval stage	Fore-gut mm.	Mid-gut mm.	Hind-gut mm.	Alimentary canal mm.	Body-length mm.
Frst instar	0·0027	0·0259	0·0073	0·0360	0·0135
Second instar	0·0032	0·0285	0·0106	0·0424	0·0159
Third instar	0·0035	0·0414	0·0084	0·0497	0·0196

We further find from the maximum amount of growth of structures that the mid-gut developed 5·66 times of the original whereas least growth is shown by hind-gut which grows to 3·52 time of the original. The table III shows this clearly. One thing important to note is that while the total increase in body-length is 4·99 times and the total growth of the alimentary canal is 4·67 times.

TABLE III

Region of growth	Growth in mm.	Number of times of original growth
Body length	4·771	4·99
Fore-gut	0·737	4·09
Mid-gut	7·363	5·66
Hind-gut	2·193	3·52
Alimentary canal	9·916	4·67

Summary

The present study deals with the growth rate of different parts of aliment-ary canal in relation to its body-length. The just hatched larva measures 1·193 mm. in length, while the alimentary canal measures 2·698 mm. Ratio between the total body length and that of alimentary canal was 1 : 2·2. In the full-grown first instar larva the body length increased by 0·944 mm. whereas the alimentary canal grew 2·172 mm. longer and thus still maintaining a ratio of 1 : 2·2.

In the early second instar the ratio between body length and alimentary canal has increased to 1 : 2·4, and this ratio decreases to 1 : 2·3 before the second moulting. In the just moulted third instar larva ratio between body length and alimentary canal was 1 : 2·2, whereas at the time of maximum development ratio increases to 1 : 2·5. Before moulting of larva into pupa the internal structures show contractions and the ratio between body length and alimentary canal now becomes 1 : 1·8.

From this study we find that : (i) There is no fixed rate of growth for the alimentary canal of this insect. (ii) The ratio between the rate of growth of body length and total alimentary canal though not fixed for all stages but varies little excepting for just before pupating, when the larva shrinks and prepares to moult for pupation. (iii) Similarly the rate of growth of the different structures shows that there is no fixed rate of growth. (iv) The total increase in body length 4·99 is times and the total increase of the alimentary canal is 4·67 times of original.

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STUDIES IN THE MONOCOT FLORA OF ASSAM AND NORTH-EAST FRONTIER AGENCY

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Realising that the Flora of British India by Sir J. D. Hooker (1872–1897), however comprehensive at the time, could not serve the needs of the present, taxonomists like Burkill (1924), Bor (1938), Fischer (1938) etc., undertook tours in certain parts of Assam and N. E. F. A., but the collections made by them could only be sporadic due to inaccessibility of the mountaineous regions especially in N.E.F.A., mainly owing to the absence of transport facilities during their time. Again, the publication of the Flora of Assam (1934–1940) by Kanjilal, Kanjilal, Das, Purkayastha, Dey, Bor *et al.* also leaves a serious gap in the knowledge of the Flora of this region owing to the non-inclusion of monocots (except Gramineae) and many other herbaceous dicotyledonous plants occurring indigenously in the area. Mitra's (1958) Flowering plants of Eastern India touches barely the fringe of the problem and leaves much to be desired. Subsequently, Kingdom Ward made some collections in the Lohit valley and in Dirang Dzong areas of N. E. F. A. and Srinivasan (1959) has published an account of the collections made by him between the foot-hill and Bomdila of the Kameng Frontier Division in May, 1955. Again, Panigrahi and Naik (1961) dealt with the geology, topography and vegetation between Kimin to Zero and have appended an enumeration of about 450 species collected from Subansiri Frontier Division in September, 1959. Yet, it must be admitted that the progress in the study of systematic botany and taxonomy of the flora of this area has been very slow indeed and vast tracts of this mountaineous country still remained unexplored botanically.

Accordingly, Department of Botanical Survey of India launched a special scheme for compiling the Monocot volume of Flora of Assam with the exception of Gramineae.

In pursuance of a well-planned programme of work, fairly large number of tours were undertaken in different parts of Assam and N. E. F. A. between 1956-62, the vegetation was studied, and sample collection of botanical specimens were made from varying altitudinal heights ranging from 30 m. in the plains of Assam to about 4500 m. in the interior Himalayan ranges of N. E. F. A. The areas visited, the period and the duration of visit and the total field numbers collected from each area are shown in Table I. Since Assam and N. E. F. A., two administrative units politically, constitute one inseparable phytogeographical unit, this paper outlines the broad characteristic features of the topography, vegetation, and the climate and presents a combined picture of the monocot flora of the region.

Topography :

Geologically speaking, parts of Assam and the whole of N. E. F. A. area are of recent origin, generally attributed to tertiary or pleiostocenic formations whereas the southern parts of Assam namely, Garo Hills, Khasi and Jaintea Hills, and Mikir Hills contain a very ancient core of rock belonging to Gondwana age. Thus, different regions of Assam and N. E. F. A. belong to different geological ages.

Traditionally, the region is classified into four different topographical divisions from north to south, such as—

(1) The Eastern Himalayas.

(2) The Brahmaputra valley.

(3) The Central Assam Range.

(4) The South-Eastern Hill country.

(1) *The Eastern Himalayas.*—It comprises all areas to the north of Brahmaputra valley upto the Tibetan border on the north, Bhutan border on the west and Burma border on the east. The origin of the region is attributed to tertiary—folding while some parts on the north east shows evidences of volcanic activities in the remote past. At certain places, the tertiary beds are seen lying below much older Archean or Cambrian rocks, evidently due to the horizonal thrusts from the north-west during the origin of the Himalayas. The whole area consists of steep hills and deep gorges, some of the ranges in India-Tibet border reaching upto 4270 m.

(2) *The Brahmaputra valley.*—This valley is conveniently divided into Upper Assam and lower Assam limited by a north line joining Tejpur and Nowgong. The upper Assam constitutes the alluvial plains lying between the N. E. F. A. in the north-east and the Naga Hills in the south while the lower Assam is broken up by low hills, such as at Dhubri, Tejpur, Garbhanga and Gauhati. These hills belong to the same metamorphic complex as Shillong plateau and consists mostly of gneiss. In the centre of the valley lies the alluvium, several hundred meters in depth and is very fertile. A number of rivers, rivulets and streams which channel through this valley help in creation of the large swamps and bheels *viz.* at Motharguri, Kaziranga etc.

(3) *Central Assam Range.*—This comprises of the Garo Hills, Khasi and Jaintia Hills, North Cachar and Mikir Hills. Its western half is a broken plateau showing very little tertiary folding and attains 1920 m. in height at Shillong Peak. It slopes gradually towards north but is very abrupt in its southern slope and over-looks the Surma valley (E. Pakistan). This range contains metamorphic rocks of very great age and is considered as forming parts of the Gondwana land continent. Large parts of the southern foot hills consists mainly of gneiss with very little mica but possesses large coal seams, thick limestones at Cherrapunji and sandstone beds at Dawki ; the beds being largely horizontal lie almost on the surface.

But the eastern edges of this range comprise irregular hills of North Cachar showing very intricate folding and overthrust faults.

(4) *The South-Eastern Hill country.*—This comprises mainly of Naga Hills and Lushai Hills and also, include the hills of Manipur. These hills are characterised by the presence of large faults. Serpentine intrusions are seen in the extreme east, while south-west of Naga Hills possesses thick coal-seams. The hills are interspersed with steep and narrow valleys with few level stretch of alluvium.

Soil

The nature of soil-cover in the different topographic divisions is as varied as their geological structure. The soil is sandy clay at Sissini and sedimentary

mica type at Chakoo in the Kameng F. D. The forest floor in the foot hills and beyond upto 2440 m. in Kameng, Subansiri and Tirap F. Divisions is covered over by debris of leaf humus, and often to 60 mm. in depth, arising mainly due to the shedding of leaves from year to year, over centuries. Although the general topography of Tirap F. D. is the same as of other divisions where, however, the highest hill between Raho and Waka reaches upto 1640 m., these hill ranges consist of brown black alluvium and are very stable and land slides seldom occur even in heavy rains in contrast with the Lohit F. D., in particular.

All the N. E. F. divisions are cut up by many swift flowing streams and waterfalls, joining the main rivers Kameng, Subansiri, Siang, Lohit and Borab (Tirap). The regions approaching the various streams and river beds are predominantly sandy. The slope of Khasi and Jaintia hills and Mikir hills possesses tropical red earth whereas on the ridges there is a gritty soil derived from the disintegration of metamorphic rocks. The lower slopes of the Naga Hills have a thick layer of sandy loam derived from the weathering of sandstones. These areas, as well as the northern parts of Brahmaputra valley which are characterised by a heavy clay of acidic soil of yellowish colour, rich in organic material, are very suitable for tea cultivation. The soil in the lower Assam valley is composed of recent alluvium and the subsoil consists of coarse water-borne pebbles with a cover of sandy loam of varying depth and over it lies a deposit of layer of humus. Near about Motharguri in N. Kamrup, the soil is rocky mixed with alluvium and gravel, while in Darrang district the bed of river Bhoreli is full of gravels.

Climate

The area is characterised by moderate temperature, heavy rainfall, high relative humidity, favourable distribution of rainy days in different parts of the year and complete absence of frost except in high altitudes of Eastern Himalayas. Consequently, there is no seasonal variation in temperature. 75% of precipitation is received between the months of June to October. Recently, Bagnouls-Gaussen (1960) has proposed a bioclimate map of India in which Assam and N. E. F. A. areas are divided into five different belts based on the temperature of the coldest months, number of dry months in a year and period of frost in higher altitudes.

(a) Almost the whole of Assam except Central range and Naga Hills is governed by Mesoxerochimenic bioclimate characterised by 3-4 dry months in a year and by the temperature of the coldest month exceeding 15°C.

(b) The Central range of Assam, Naga Hills Tuensang area, the entire sub-tropical and temperate belt of N. E. F. A, extending from Tirap Frontier Division in the east to Kameng Frontier Division in the west is governed by submesoxeric bioclimate with 1-2 dry months, temperature of the coldest month being less than 15°C.

(c) The mesobixeric type operates in the tropical and subtropical belt of the Eastern Himalayas in the N. E. F. A. bordering the north of Brahmaputra valley. This region is said to be characterised by 5-6 dry months in a year and by the temperature dropping below 15°C in the coldest month of the year.

(d) The temperate cold or cold axeric type operates in temperate and sub-alpine regions and lie north of the submeroxeric region in the N. E. F. A. area. This type experiences less than four months of frost, and has only one dry long period.

(e) The alpine Himalayas forming two restricted pockets in the cold axeric region is covered with frost and experiences cold throughout the year. The climate in this region is termed as crymeric.

Vegetation

The vegetation of Assam and N. E. F. A. is classified under varied types. Their special distribution and dominant components have already been detailed in a separate communication (Rao and Panigrahi, 1961). The main types are as follows :

1. *Tropical evergreen and semi-evergreen forests.*—These types are found in the foot hills of Himalayas and Chirang Reserve and Haltugaon Reserve in Goalpara district, Nunai Reserve, Orang, Khalingduar in Darang district, Nambur Reserve in Sibsagar, Katakhal Reserve in Cachar, Upper Dihing, Dulong and Ranga Reserve of the North Lakhimpur district and Loharband and Narpur Reserves in Cachar district.

2. *Tropical moist and dry deciduous forests.*—These type are of rarer occurrence and are found only in northern parts of Goalpara district and towards north of Tezpur in Darrang district, while tropical deciduous Sal forest occurs in Rani, Jarasal, Kulsi and Garbhang reserves of South Kamrup and Charduar, Dhariketi etc. in Darrang district.

3. *Subtropical mixed forest.*—This is found in certain inaccessible parts of K. & J. Hills, Naga Hills in Assam and parts of N. E. F. A., such as, Bhairabkund Nyukmadong, Zang, Bomdi La, Rupa to Jabrang, Peri La in Kameng Frontier Division, near Zorum Basti in Dafla Hills, near Sirang along the bank of the river Siang upto Tibet border in Siang Frontier Division, near Dreyi in Lohit Frontier Division and at places like Niusa, Waka etc. in Tirap Frontier Division.

4. *Subtropical pine forest.*—This forest type is rather an artificial one and occurs in areas such as Shillong plateau, Nongstoin area in the Khasi and Jaintia Hills, near Zang, Bumla etc. in Kameng Frontier Division.

5. *Temperate mixed forest.*—Areas, such as, Senge Dzong, Towang, Bumla, Zang in Kameng Frontier Division, Apatanang valley (Hapoli) in Subansiri Frontier Division, from Sirang to northern side upto Tibet border in Siang Frontier Division, and eastern part of Lohit Frontier Division are characterised by this type.

6. *Temperate pine forest.*—Occurrence of this type of forest is not common but is found near Senge Dzong in Kameng F. D., in Apatanag valley in Subansiri F. D.

7. *Subalpine and alpine vegetation.*—Very high altitudes at Sela in the Kameng F. D., and near Heyuliang in Lohit F. D. are characterised by sub-alpine and alpine vegetation.

8. *Tropical grassland.*—The banks of Manas river in the Motbarguri area in the Kamrup district, Kaziranga Reserves in the Sibsagar district and the foot of Mikir Hills in Assam are swamps covered by grassland vegetation.

9. *Subtropical grassland.*—Cherrapunjee, Nongstoin, Jowai areas in the Khasi and Jaintia Hills of Assam and the region between Kherbari and Haploi in the Subansiri F. D. and between Tinchha and Laju and again, at Niusa area in the Tirap Frontier Division, N. E. F. A. are characterised by a Subtropical grassland vegetation.

An enumeration of the total number of species of Monocots of Assam and N. E. F. A. collected by the Eastern Circle of the Botanical Survey of India together with those of the former herbarium of the Assam Forest Department with the exception of the two families, viz. Gramineae and Orchidaceae, reveal the existence of 145 genera and 540 species belonging to 24 families of Bentham and Hooker's system. The family Philydraceae, however, appears to be unrepresented in the area. Recent collections of Botanical Survey of India have revealed hardly any new taxa of the grasses not already included in the most comprehensive and uptodate treatment of the family Gramineae by Dr. N. L. Bor (1940 and 1960). Family Orchidaceae is being treated under a separate scheme viz. 'National Orchidarium'.

Of these 540 species referred to above, the five dominant families, viz. Cyperaceae (134 spp.), Scitamineae (75 spp.), Liliaceae (70 spp.), Araceae (60 spp.) and Palmae (28 spp.) share among them 367 species. It is interesting to observe that of the 134 spp. of Cyperaceae 67 species belong to two genera viz. Carex (39 spp.) and Cyperus (28 spp.). Similarly, amongst the genera with larger number of species in this area are Smilax with 17 spp. and Hedychium with 16 spp. and many varieties. On the other hand, families like Bromeliaceae (Genus 1 : sp. 1), Taccaceae (Genus 1 : spp. 3), Xyridaceae (Genus 1 : spp. 3), Flagellariaceae (Genus 1 : spp. 1) and Pandanaceae (Genus 1 : sp. 3) are poorly represented in Eastern India and stand in good contrast with the dominant families cited above. But the families Dioscoreaceae and Eriocaulaceae, though represented by one genus each, are widely distributed, Dioscorea with 24 spp. and Eriocaulon with 14 spp, in the area. On the other hand, 17 genera viz. Hydrilla, Nechamandra, Streptopus, Theropogon, Gonioscypha, Hemerocallis, Asphodelus, Dianella, Gloriosa, Tricyrtis, Paris, Flagellaria, Pistia, Thomsonia, Lasia, Tenagocharis and Courtoisia represented by only one species in India also occur in Assam and N. E. F. A.

The widely distributed species in this area are : Hedychium coronarium Koenig and its varieties, Hitchenia careyana (Wall.) Benth., Costus speciosus (Koenig) Sm., Alpinia allughas (Retz.) Rosc., A. malaccensis (Burm.) Rosc., Curculigo recurvata Dryand, Dioscorea bulbifera Linn., Monocharia hastaefolia Presl, Calamus floribundus Griff., Colocasia esculenta (Linn.) Schott., Cyperus brevifolius (Rottb.) Hassk., Scleria tessellata Willd., and S. cochinchinensis (Lour.) Druce and many of them also extend their range of distribution elsewhere in India.

In contrast, Aletris khasiana Hook. f. (Upper Shillong, (S. L. 15117), Ophiopogon dracaeloides (Bak.) Hk. f. (Kohima, Bor 15814), Dioscorea scortechinii Pr. & Burk. (Garampani in Sibsagar district U. N. Kanjilal 1921), Polygonatum griffithii Baker (Shoeliang in Lohit F. D., Rolla 10518), P. hookeri Baker (Senge Dzong in Kameng F. D., Rolla 7708), Gonioscypha eucomoides Baker (Brukpalanchen in Kameng F. D., Panigrahi 15684), Eleocharis fistulosa (Poir.) Schultz. Barapathar in Sibsagar, S. L., S. N., Scirpus maritimus Linn. (Lawlynghdoh in Khasi & Jaintia Hills S. L. 15975), Scleria annularis Kunth (Cherapunji—S. L. 986), are species with very restricted distribution.

Many species collected from Assam and N. E. F. A. area are found widely distributed in the neighbouring regions as shown in Tables II and III. Only 19 of the 540 species collected have turned up as endemics to this region, thus indicating hardly 4 per cent endemism in the monocot flora.

An analysis of the available data on distribution of species shows that the percentage of monocot flora in the tropical and sub-tropical altitudes is much

higher than the percentage occurring in temperate and sub-alpine situations. Most of the species of *Helychium*, *Alpinia*, *Musa*, and *Costus speciosus* Sm. restrict themselves to the borders of the tropical forest and are never seen growing under the shade in these forests, while species of *Zingiber*, *Amomum*, *Peliosanthes*, *Curculigo*, *Amorphophalus* etc. seldom expose themselves to sun light and grow comfortably below the trees as undergrowths. *Roscoea* spp., *Cautleya* spp., *Polygonatum oppositifolium* Royle, *P. cathcartii* Baker, *Heterosmilax indica* A. D. C. *Tupistra aurantiaca* Wall., are the characteristic elements of the sub-tropical evergreen forests. The species characteristic of the temperate forests are also in a considerable number. They are *Iris* spp (and probably the whole family). *Dioscorea kamoonensis* Kunth, *D. deltoidea* Wall., *Smilax parviflora* Wall., *Polygonatum* spp., *Smilacina* spp. *Lilium cordifolium* Don and *Arisaema consanguineum* Schott etc., some of which, however, descend down to sub-tropical forests. Species commonly found in the grasslands, both sub-tropical and tropical, are innumerable, as the whole family Cyperaceae is found on the margins of ponds and in marshy areas, together with *Phrynium capitatum* Willd., *Hemerocallis fulva* Linn., *Iphigenia indica* Kunth, *Chlorophytum* spp., *Xyris* spp., *Juncus* spp., *Typhonium trilobatum* (Linn.) Schott., *T. flagelliforme* (Roxb.) Bl. and *Eriocaulon* spp. etc. Very few species extend to sub-alpine and alpine regions and are very rare in such situations. Of these mention may be made of *Polygonatum hookeri* Baker, *Smilacina oligophylla* Hk. f., *Fritillaria cirrhosa* D. Don, *Juncus grisebachii* Buch.-Ham. etc.

In contrast to the small number of endemic species referred to earlier, a larger number of species are distributed elsewhere in India (Table II) and outside India (Table III).

It is thus evident that a large number of species from neighbouring regions have found their way to Assam and N. E. F. A. which has served as a meeting ground for Malayan-Burmese elements on the one hand and Peninsular India elements on the other. This may corroborate the accuracy of the floristic divisions to which the area has been divided by Good (1953).

TABLE II		TABLE III	
Species common to—	No.	Species common to—	No.
Bengal-Bihar	41	Sikkim & Bhutan	120
Western Himalayas	40	Burma & Malaya	98
Manipur	35	Nepal	58
Deccan Peninsula including Concan & Malabar	51	Ceylon	45
		China	42
Nilighiri & Pulney Hills		Australia	25
Andaman & Nicobar Islands	8	Africa	15
Throughout India	86		

The occurrence in Assam of certain number of species common to Africa and Australia seems rather intriguing. Species common to Africa include *Dioscorea pentaphylla* Linn., *Potamogeton octandus* Poir., *Eriocaulon xeranthemum* Mart., *Kyllinga triceps* Rottb., *Cyperus eleusinoides* Kunth, etc. and those common to Australia are *Burmannia disticha* Linn., *B. coelestis* Don, *Dracaena angustifolia* Roxb., *Potamogeton perfoliatum* Linn., *Cyperus cephalotes* Vahl, *C. pilosus* Vahl, *Rhyncospora wallichiana* Kunth etc.

Species listed below have turned out as new records for the area ; their distribution and field characters and other relevant data are indicated against each :

1. **Musa nepalensis** Wall F. B. I. 6 : 261.

   Wild, with green fruits and violet bracts. Collected for the first time from Pangsu Pass in Tirap F. D., N. E. F. A. (*Rolla* 20165). Earlier distribution : Nepal.

2. **Juncus glaucus** Ehrh. F. B. I. 6 : 393.

   Perennial, on the sandy bed of streams and on dry grassy slopes etc. ; stem cylindrical, brown at base ; flowers brownish. Collected from Jegaon (*Panigrahi* 6698), Shergaon (*Panigrahi* 15754) and Nyukma-dong. (*Rolla* 7606) in Kameng F. D., N.E.F.A. Earlier distribution. West Himalayas from Kashmir to Nepal, Nilghiri Hills, Ceylon etc.

3. **Carex myosurus** Nees F. B. I. 6 : 723.

   Aerial stem upto 1 m. high, inflorescence not conspicuous. Collected from Sissini (*Panigrahi* 6071) in Kameng F. D., N. E. F. A. Earlier distribution : Nilghiri and Pulney Hills, Courtallum.

4. **Zalacca secunda** Griff F. B. I. 6 : 472.

   Commonest perennial palm without aerial stem ; leaves about 5 m. in length, thorny ; young infloresence axis dark brown. Collected from the valleys between Banfera and Longhwa (*Panigrahi* 16742) in Tirap F. D., N. E. F. A. Earlier distribution : Rangoon.

TABLE I

Areas visited by BSI/EC, Shillong	Period and duration of visit	Collector	No. of monocot species (*i.e.* fields nos.) collected
Assam			
Khasi & Jaintia Hills dist.			
Cherapunji	June, Sept. Dec. (9 days)	R. S. Rao & G. Panigrahi	58
Pynursla	August (3 days)	G. Panigrahi	30
Jowai & Garampani	May, October (6 days)	G. Panigrahi & R. S. Rao	33
Umtrue & Barapani	November (4 days)	G. Panigrahi	16
Nongstoin & Nangkhlaw	June (6 days)	G. Panigrahi	42
Shillong and surround-ings	Various seasons	G. Panigrahi & G. K. Deka & others.	

Areas visited by BSI/EC, Shillong	Period and duration of visit	Collector	No. of monocot species (*i.e.* field nos.) collected
Kamrup dist.			
Garbhanga, Rani, Jarasal & Kulsi R. F. s.	May (4 days)	G. Panigrahi	28
Manas & Motharguri R.F.s	July (5 days)	R. S. Rao	15
Goalpara dist.			
Chirang and Haltugaon R. F.s	April (3 days)	R. S. Rao	12
Darrang dist.			
Charduar, Dhariketi	February (10 days)	G. Panigrahi	20
Khalingduar R. F.	April (5 days)	B. K. Nath	13
Singri R. F. and Orang	July (4 days)	G. Panigrahi	21
Cachar and Mikir Hills dists.			
Foot Hills of Mikir Hills	May & August	R. S. Rao &	33
Deygrum, Katakhal R.F.s etc.	(8 days)	G. Panigrahi	
Nowgong dist.			
Silghat area	February (4 days)	G. Panigrahi	9
Sibsagar dist.			
Baguri, Nambor Kaziranga R.F.s	May & Sept. (8 days)	G. Panigrahi & R. S. Rao	35
Lakhimpur dist.			
Dibru-Kakajan R.F.s	October (7 days)	G. Panigrahi	37
Upper Dihing R.F.	July (3 days)	G. Panigrahi	23
Kokoi, Ranga & Dulong R.F.s	November (7 days)	G. Panigrahi	34
Garo Hills dist.			
Tura top, Baghmara, Rong-Rongeri R.F.s	November (7 days)	G. Panigrahi	28
N.E.F.A.			
Kameng F. D.			
Foot Hills to Bomdila and beyond to Towang and Brukpalanchen in Bhutan border to Bhairabkunda in the south and Rupa in east.	March, April, May (38 days) May, June (32 days)	G. Panigrahi R. S. Rao	158 27

Areas visited by BSI/EC, Shillong	Period and duration of visit	Collector	No. of monocot species (*i.e.* field nos.) collected
Subansiri F. D.			
From Kimin to Ziro	September (12 days)	G. Panigrahi	38
Siang F. D.			
Tuting, Koppu, Geling, Kepangla, Pongu, Sairang Eyo. Along etc.	November (27 days)	R. S. Rao	46
Lohit F. D.			
Digaru to Heyuliang	November-December (27 days)	R. S. Rao	43
Tirap F. D.			
Chenglang, Laju, Waka, Niusa, Wanu, Banfera, Rusa. Pangsupass.	August-September (20 days)	G. Panigrahi	60
Margherita-Jairampur, Nampong, Pangsupass, Namchik.	October (14 days)	R. S. Rao	33

Summary

The paper outlines the broad characteristic features of the topography, vegetation and the climate and presents a combined picture of the monocot flora of Assam and North East Frontier Agency on the basis of the study of specimens collected from the area and deposited in the Central National Herbarium, Howrah (Calcutta), Forest Research Institute, Dehra Dun (DD) and Eastern Regional Herbarium of the Botanical Survey of India, Shillong (Assam). It discusses the distribution of 540 species belonging to 145 genera and 24 families of Bentham and Hooker's system and records *Musa nepalensis* Wall., *Juncus glaucus* Ehrh., *Carex myosurus* Nees and *Zalacca secunda* Griff. as new records of species for the area.

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AN ANALYSIS OF THE TREMATODE GENUS *ORIENTOCREADIUM* TUBANGUI, 1931

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Fischthal and Kuntz (1963) have given a critical review of the genus *Orientocreadium* Tubangui, 1931 and a general discussion about the synonymy of the genera *Paratormopsolus* Bychowsky and Dubinina, 1954, *Ganada* Chatterji, 1933, *Neoganada* Dayal, 1938, *Nizamia* Dayal, 1938, *Ganadotrema* Dayal, 1949 and *Macrotrema* Gupta, 1951. Yamaguti (1958) created the subfamily Orientocreadiinae to include the genera *Orientocreadium* and *Macrotrema* under the family Allocreadiidae. Skrjabin and Koval (1960) created the family Orientocreadiidae and kept in Lepocreadioidea Cable, 1956. Fischthal and Kuntz (1963) invalidated the subfamily Orientocreadiinae, indicating only two valid Plagiorchid genera, viz., *Orientocreadium* Tubangui, 1931 and *Ganada* Chatterji, 1933 in it. They suggested that these genera can be placed either in Plagiorchiidae or partly in the latter and partly in Brachycocliidae.

Fischthal and Kuntz (1963) consider that the tubular and Y-shaped excretory bladder should have a generic significance. The species having tubular excretory bladder should be separated from the species having Y-shaped excretory bladder. On this basis they consider *Orientocreadium* and *Ganada* as the valid genera and they have shown *Neoganada*, *Nizamia*, *Ganadotrema* and *Macrotrema* synonymous to the genus *Ganada*. They consider *Orientocreadium batrachoides* Tubangui, 1931, *O. indicum* Pande, 1934 and *O. pseudobagri* Yamaguti, 1934 as valid species of the genus *Orientocreadium* and *O. raipurensis* Saksena, 1958, *O. dayalai* Saksena, 1958, *O. umadasi* Saksena, 1960 and *O. lazeri* Khalil, 1961 synonymous to *O. batrachoides*. The synonymy of some of the species included in the genus *Ganada* have also been discussed by them.

Creation of the family Orientocreadiidae Skrjabin and Koval (1960) seems unnecerary. The author supports Mehra (1962) in shifting the subfamily Orientocreadiinae from Allocreadiidae to Lepocreadiidae Nicoll, 1934 on two reasons, firstly, because of the presence of vesicula seminalis externa and secondly, on the basis of chromosome morphology. Britt (1947) reported that large chromosomes occur in the family Allocreadiidae. Chromosomes of *Orientocreadium umadasi* Saksena, 1960, as studied by the author (1963) are small. However, the author accepts the view of Fischthal and Kuntz (1963) that, in absence of the knowledge of the life cycle of any of the forms included in the subfamily Orientocreadiinae, their systematic position is still a subject to debate and a matter of personal preference.

The author accepts the view of Fischthal and Kuntz (1963) that the tubular and Y-shaped excretory bladder should have a generic significance in spite of the similarities of other structural characters. The validity of the genus *Ganada* Chatterji, 1933 and the synonymy of the genera *Neoganada*, *Nizamia* and *Ganadotrema* to the genus *Ganada* are accepted on the above basis. However, the author

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cannot possibly accept the synonymy of the genus *Macrotrema* Gupta, 1951 to the genus *Ganada* shown by Fischthal and Kuntz (1963). Very long oesophagus shifting the position of intestinal bifurcation near to ventral sucker in *Macrotrema microni* Gupta, 1951 cannot be ignored. In addition to the above character, decidedly diagonal position of testes, ovary larger than testes and anterior extension of vitellaria upto anterior level of acetabulum or even beyond it should also be considered. All these characters taken in conjunction definitely justify the validity of the genus *Macrotrema*.

Fischthal and Kuntz (1963) declare *Orientocreadium raipurensis* Saksena, 1958, *O. dayalai* Saksena, 1958 and *O. umadasi* Saksena, 1960 synonymous to *O. batrachoides,* overlooking the fact that in the above three species the cirrus is spiny. (They are incorrect to state under *Orientocreadium raipurensis* Saksena, 1958..... ."It can be differentiated from *O. indicum* in having unspined cirrus and metraterm" ......Fischthal *et al.* (1963) : Page 456. The author had definitely stated in his papers that the cirrus is spiny.—Saksena (1958) : Page 59 line 30, page 61 line 9 ; Saksena (1960) : Page 84, line 16). On the basis of spiny nature of cirrus and metraterm they have accepted the validity of *O. indicum.*

Orientocreadium raipurensis, O. dayalai and *O. umadasi* may come nearer to *O. indicum* Pande, 1934 on the basis of the spiny cirrus. The prepharynx in *O. umadasi* is decidedly long. This character has been found constant in the further collection of parasites from different regions of Madhya Pradesh (India). Bilobed nature of vesicula seminalis externa is more pronounced in some while in others it is less pronounced, but the constriction is always present to differentiate the two parts of the vesicula seminalis extenra. The long length of prepharynx has been sufficiently established in these trematodes and on this basis the author considers *O. umadasi,* a distinct species. It is further differentiated from *O. indicum* by the suckers being approximately equal and the anterior extension of the vitellaria upto the level of ovary.

O. raipurensis has been differentiated from *O. indicum* on the basis of relative size of suckers, position and extension of cirrus sac and the vesicula seminalis externa being retort-shaped. *O. dayalai* has been differentiated from *O. indicum* on the basis of anterior extension of vitellaria, posterior testis smaller than anterior testis, prepharynx and oesophagus comparatively long and oral sucker decidedly much smaller than ventral sucker.

Beverley-Burton (1962) and Fischthal and Kuntz (1963) studied further collections of *O. batrachoides* and reported variations in external seminal vesicle, extension of cirrus sac and the form of strap-shaped vitelline follicles forming a lattice. Intraspecific variations are likely to occur in *O. indicum* as well on the same lines. *O. raipurensis* were collected twice and *O. dayalai* once only. They were not available later on for re-study. Of course, it is difficult to judge the limits of intraspecific variations of different species. Further population studies of the Indian species of *Orientocreadium* and their cytological studies might throw more light over this.

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ON A NEW CESTODE, *COLUMBIA ALLAHABADI* N.G., N.SP., FROM THE INDIAN PIGEON, *COLUMBA LIVIA* (GMELIN) FROM ALLAHABAD (INDIA) WITH A REVISION OF THE KEY TO THE VARIOUS GENERA OF THE SUBFAMILY, THYSANOSOMATINAE (SKRJABIN, 1933)

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The examination of the intestines of pigeons, for the last six months has disclosed a number of interesting forms of cestodes one of which is considered in the present paper. A detailed morphological study of the present form has revealed it to belong to the subfamily Thysanosomatinae Skrjabin, 1933 (Anoplocephalidae Cholodkovsky, 1902). The form possesses a sac like paruterine organ and a transverse lobulated uterus, the characters which warrant the erection of a new genus.

COLUMBIA N.G.

Generic diagnosis.—Family Anoplocephalidae ; subfamily Thysanosomatinae, Scolex not distinctly seperated from strobila, with 4 muscular. cupshaped, un-armed suckers. Rostellum absent. The neck is short. Proglottids much wider than long. Proterandrous. Ovary submedial, poral, bilobed. Vitelline gland postoverian, compact and transversely elongated. Testes many, in two lateral groups, separated by the ovary. Uterus a transverse lobulated sac. Common genital openings alternate irregularly. Genital ducts medial. Cirrus sac small, muscular not reaching the longitudinal excretory canal. Vesicula seminalis interna and externa (?) present ; Vagina irregularly dorsal and ventral to cirrus sac.

Type species ; *COLUMBIA ALLAHABADI*, N.SP.

Description : (Measurements in mm.)

(Figs. 1, 2, 3, 4)

Scolex not well demarcated from the body, rectangular (length 0·118, width 0·177). Suckers 4, unarmed, muscular and cup shaped (diameter 0·088) Rostellum absent. Short neck present (length 0·236). Proglottids broader than long (average measurement : Mature proglottids length 0·384-0·443, width 5·5., Gravid proglottids length 0·443-0·694, width 5). Dorsal excretory canals narrower than ventral canals and extending up to the middle region of the strobila. Proterandrous. Testes numbering 75-120 (average diameter 0·029) disposed in two lateral groups, seperated by the ovary. Ovary submedial, bilobed, poral.

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Vitelline gland compact ; postovarian (width 0·147–0·265). Genital ducts medial. Vagina opening irregulary into common genital atrium on the dorsal and ventral sides of the cirrus sac. Cirrus sac elongated, muscular tube (length 0·147–0·221 ; width 0·029-0·073), not reaching the excretory canal of its side. Vesicula seminalis interna (size 0·073×0·029-0·118×0·044) and vesicula seminalis externa (?) present.

Uterus, a transverse fissure initially, transforms later into a transverse sac and extends upto excretory canal on either side (average size 4·354×0·295). Paruterine organ single sac like (size 0·147×0·088–0·398×0·265).

Eggs, minute, spherical (average diameter 0·014) numerous, filling the uterus.

      Host : *Columba livia* (Gmelin)

      Locality : Allahabad, U. P. India.

      Specimen : Museum, Zoology Department, Allahabad University, Allahabad (India)

Discussion

Thysanosomatinae Skrjabin, 1933 includes 8 genera (Yamaguti, 1959 viz. *Thysanosoma* Diesing, 1835 ; *Anootypus* Woodland, 1928 ; *Ascotaenia* Bear, 1927 ; *Avitellina* Gough, 1911 ; *Stilesia* Railliet, 1893 ; *Thysaniezia* Skrjabin 1926 ; *Wyominia* Scott, 1941 from mammals and the only genus *Mogheia* Lopez-Neyra, 1944 (syn, *Baeria* Moghe, 1933) from birds.

A comparision of all the genera discribed under the subfamily Thysanosomatinae reveals that the present form is distinguishable from *Thysanosoma* and *Wyominia* in the absence of double set of genetalia. It also differs from *Ascotaenia Stilesia* and *Thysaniezia* in the possession of only one paruterine organ. It resembles *Anootypus*, *Avitellina* and *Mogheia* in having single paruterine organ. But *Anootypus* and *Avitellina* differ from it in the presence of fewer number of testes and absence of a definite vitelline gland. *Mogheia* appear to be the closest ally of the present material. These resemble each other in the presence of single paruterine organ, small cirrus sac, irregularly alternate genital openings, medial genital ducts and proglottids wider than long. But differ in the following respects.

1. Proglottids of *Mogheia* are narrower than the scolex while those of the present form are much wider than the scolex.

2. Testes numbering 8–9 in the former while 75–120 in the latter.

3. Vesicula seminalis interna absent in former while present in the latter.

4. Uterus in *Mogheia* is submedian globular sac occupying the whole length of the proglottid while in the present material it is a transverse lobulated sac reaching the longitudinal excretory canals on either sides.

In the light of the above discussion it can be very well concluded that the form differs from all the reported genera of the subfamily Thysonosomatinae. It is therefore necessary to erect a new genus, *Columbia* for the reception of the present meterial.
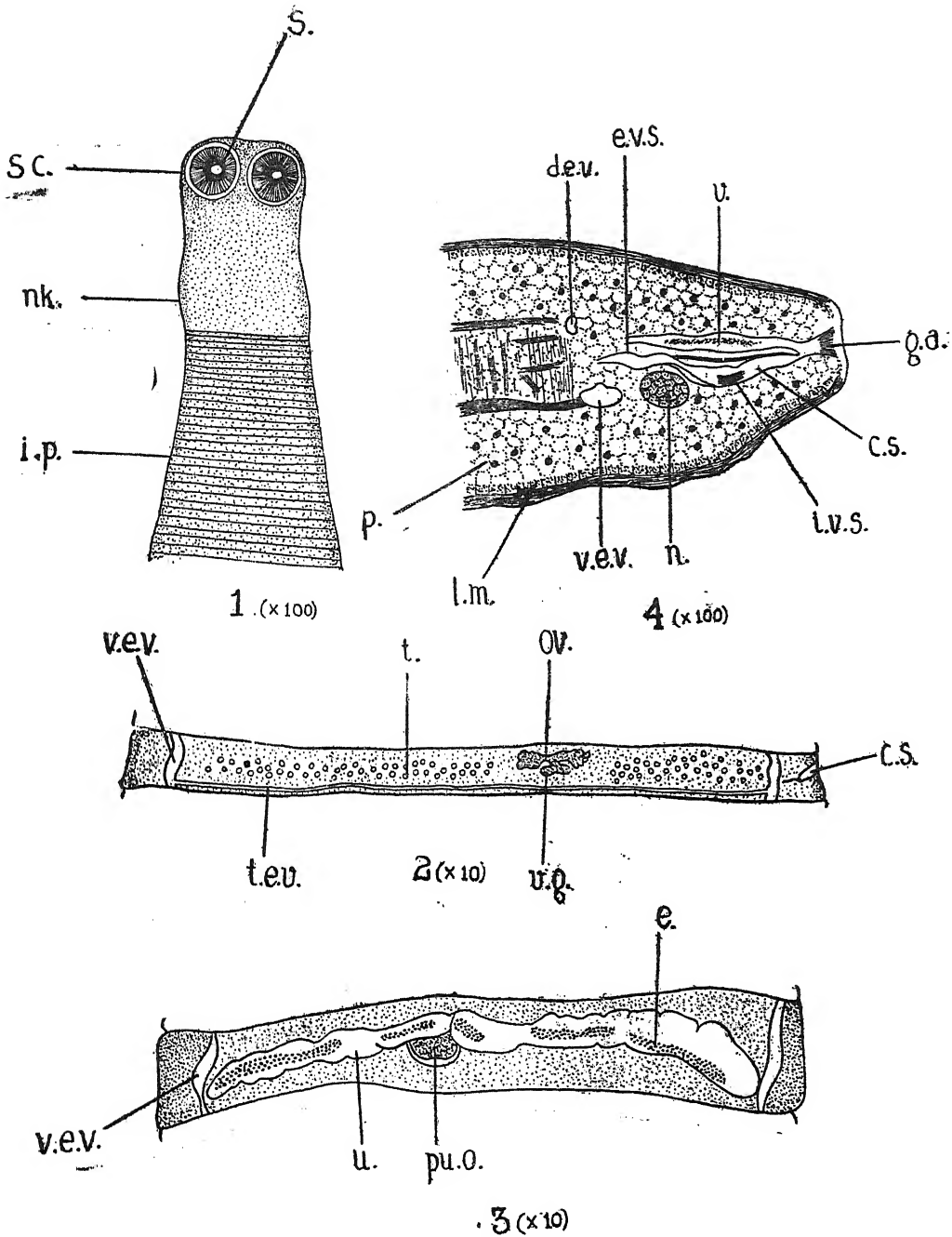
EXPLANATION OF THE PLATE

Figures. 1. Scolex with neck ; 2. Mature proglottid ; 3. Gravid proglottid ; 4. Transverse section showing the terminal genital ducts.

c.s. Cirrus sac ; d.e.v. Dorsal excretory vessel ; e. Eggs ; e.v.s. External vesicula seminalis ; g.a. Genital atrium ; i p. Immature proglottid ; i.v.s. Internal vesicula seminalis ; l. m. Longitudinal muscle ; n. Nerve ; nk. Neck ; ov. Ovary ; p. Parenchyma ; pu.o. Paruterine organ ; s. Sucker ; sc. Scolex ; t Testes ; t.e.v. Transverse excretory vessel ; u. Uterus ; v. Vagina ; v.e.v. Ventral excretory vessel ; v. g. Vitelline gland.

Type genus ; *Columbia*

Type species ; *Columbia allahabadi*

Key to the genera of the subfamily Thysanosomatinae (Skrjabin, 1933)

1. Genitalia—Single per proglottid ... 2
   Double per proglottid ... 6

2. Paruterine Organ
   One ... 3
   Two ... *Stilesia*
   More then two ... 5

3. Uterus – Round sac ... *Mogheia*
   Transverse sac ... 4

4. Vitelline gland absent, testes few vagina alternately dorsal
   and ventral to cirrus sac ... *Avitellina*

   Vagina always ventral to cirrus sac ... *Anootypus*

   Vitelline gland present, testes numerous in two groups ... *Columbia*

5. Paruterine organs few, in number, testes in intravascular
   field, vitelline gland rudimentary, genital ducts dorsal to
   excretory stems ... *Ascotaenia*

   Paruterine organs very numerous testes in extravascular field,
   vitelline gland small and compact, genital ducts between
   the two excretory stems ... *Thysaniezia*

6. Posterior border of proglottid fringed. Testes occupying
   posterior half of proglottid between two ovaries ... *Thysanosoma*

   Posterior border of proglottid not fringed. Testes in a single
   row occupying anterior two thirds of proglottid ... *Wyominia*

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THE PAS REACTIVE SUBSTANCES OF THE CYTOPLASMIC ORGANELLES IN THE DEVELOPING MALE GERM CELLS OF *LYGAEUS HOSPES* (HETEROPTERA, HEMIPTERA)

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Introduction

Schrader and Leuchtenberger (1951) first initiated the investigation of the PAS reactive substances in the cytoplasm of the male germ cells of the bug, *Arvelius albopunctatus*. Later, Leblond and Clermont (1952) demonstrated the presence of mucopolysaccharides-acidic as well as basic or neutral type in the spermiogenesis of a number of mammals. Clayton *et al.* (1958), Bawa (1960), Gupta and others (1960) have worked out the histochemical details of the cytoplasmic inclusions of the male germ cells of some more insects.

In order to throw more light on the chemical nature of the cytoplasmic inclusions in the developing male germ cells, the author undertook this work.

Material and Technique

Male specimens of *Lygaeus hospes* were collected from Gorakhpur, U. P. and Muzaffarpur, their testes were taken out rapidly in normal saline and fixed immediately in cold Carnoy, in the Ludford's modification of Mann-Kopsch and in Flemming's fluid without acetic acid. The Mann-Kopsch sections were mounted without any counterstain, those of F. W. A. were stained with Iron alum and Heidenhain's haematoxylin, and those of Carnoy with leucobasic fuchsin after periodic acid oxidation. The leucobasic fuchsin was prepared according to Coleman's method (1938) and the periodic acid solution was prepared according to McManus (1946) and to Hotchkiss (1948). The PAS sections were counterstained, if desired, with methyl green or fast green. For the test of the nature of the PAS reactive substance the reversible acetylation technique of McManus and Cason (1950), hot methanol and chloroform mixture of Gersh (1949) and the PAS test after treatment of the section with diastase, hyaluronidase and pepsin were performed.

For obtaining sections from freezing microtome the technique of Baker (1944) was employed and the following histochemical tests were also performed :

1. Millon's test according to Bensely and Gersh (1933) and according to Baker (as recommended by Pearse 1961). The latter proved more useful.

2. Mercuric-bromophenol blue test as recommended by Mazia, Brewer and Alfert (1953).

3. Berg's (1926) Ninhydrin test 0·2% aq. soln. The Xanthoproteic test, Sakaguchi's test for arginine, Schultze's test for cholesterol and Sudan Black B test for lipoid were performed as recommended by Baker (1944).

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Observations

(A) *Periodic-acid-Schiff reactive substances*

In sections prepared by Carnoy periodic acid Schiff's technique, some spherical and sub-spherical bodies are stained red in the grown up primary spermatocytes (Pl. 1, fig. 1). Some of these red bodies are in contact with the nuclear membrane and the others scattered in the cytoplasm. These correspond in size and position to the internal portion of the Golgi bodies as seen in Mann-Kopsch preparation (Pl. 1, fig. 10). The Golgi externum does not show any colour. It is of interest to note that the connective tissues lining the lobes of the testis show granular PAS-positive materials stained red.

The young spermatid shows red colour in a large circular body in contact with the nuclear membrane close to the mitochondrial nebenkern which is PAS-negative (Pl. 1, fig. 2). This corresponds to that portion of the acroblast which remains lightly coloured with Mann-Kopsch or F. W. A.—haematoxylin (Pl. 1, fig. 11). No portion corresponding to the horse-shoe shaped shell of the acroblast of F. W. A.—haematoxylin preparation is visibly stained with this technique. By the time the nebenkern assumes the onion-pattern the red coloured substance of the acroblast begins to migrate to the anterior end of the nucleus, opposite the nebenkern (Pl. 1, figs. 3 & 4).

Eventually a granule of a deeper red colour appears within the red acroblast in contact with the nuclear membrane (Pl. 1, figs. 3 & 4). No vacuole corresponding to the acrosomal vesicle of F. W. A. preparations (Pl. 1, fig. 12) is visible in this preparation. As the divided halves of the nebenkern elongate further, the red acroblast with the deep red granule migrates to the posterior end of the nucleus close to the attachment of the nebenkern halves (Pl. 1, figs. 5 & 6). There it remains for a time during which the red coloured granule increases in size and staining intensity and forms the circular acrosome. The rest of the acroblast remains applied to it as a light coloured hemispherical cap (Pl. 1, fig. 7). What happens to the acroblast later on could not be observed, but as the nucleus of the sperm elongates, the acrosome becomes applied to its lateral side and also elongates with a deep red granule at its anterior tip (Pl. 1, fig. 8). The nucleus elongates further and the acrosome also enlongates extending beyond the nuclear tip in a fine needle-like process (Pl. 1, fig. 9).

No further differentiation between the elongating nucleus and the acrosome could be observed, as both became extremely thin.

(B) *Cytochemical observations*

Various reagents were employed to test further the chemical nature of the PAS reactive substances and the results are recorded in Table I.

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TABLE I

Tests Employed	Fixative used	Imbedding material used	Primary Spermatocytes			Early Spermatid				Late Spermatid		Remarks
			Golgi body		Mito-Chondria num	Acroblast		Acrosomic granule	Mito-Chondrial nebenkern	Acrosome	Nebenkern halves	
			Exte-rnum	Inter-num		Shell	Inter-num					
	1	2	3	4	5	6	7	8	9	10	11	
1. Schiff's without PA oxidation	C	P	0	0	0	0	0	0	0	0	0	
2. Schiff's stain after PA oxidation	C	P	0	+	0	0	+	++	0	+++	0	
3. PAS after acetic anhydride and Pyridine for 45 min. at room temherature	C	P	0	0	0	0	0	0	0	0	0	
4. PAS after acetic anhydride and Pyridine followed by *IN KOH	C	P	0	+	0	0	+	++	0	+++	0	
5. PAS after hot methanol and chloroform for 24 hrs. at 60°C	C	P	0	+	0	0	+	++	0	+++	0	
6. PAS after salive for 30 min. at room temperature	C	P	0	+	0	0	+	++	0	+++	0	
7. PAS after Diastase 1% for 1 hr. at 37°C	C	P	0	+	0	0	+	++	0	+++	0	
8. PAS after Hyaluronidase Wyeth 1550 USP u/mg. 5 mg./50 cc. water for 24 hrs. at 37°C	C	P	0	+	0	0	+	++	0	+++	0	
9. PAS after pepsin 5 mg. per 1 cc. of +0IN HCl for 30 min.–1 hr. at 37°C	C	P	0	+	0	0	+	++	0	+++	0	

Tests Employed	Fixative used	Imbedding material	Primary Spermatocytes			Early Spermatid				Late Spermatid		Remarks
			Golgi body		Mito-Chondria	Acroblast		Acroso-mic granule	Mito-Chond-rial nebenkern	Acrosome	Nebenk-ern halves	
			Exter-num	Inter-num		Shell num	Inter num					
	1	2	3	4	5	6	7	8	9	10	11	
10. Aq. Toluidine blue ·05-1% for 15-30 min. at room temperature	C	P	-	No meta chro-masia	-	-	No meta chro-masia	No meta chro-masia	-	No meta chro-masia	-	
11. Millon's reaction	C & FCa	Fr	0	0	0	0	0	0	++	+	++	
12. Millon's reaction after pepsin digestion 1% buffered soln. for 1 hr. at 37°C	C	P	0	0	0	0	0	0	00	+	0 0	
13. HG/BPB	C	P	+	0	0	++	0	0	+++	++	+++	(see Pl. 2, figs. 4-5)
14. Ninhydrin	FCa	P & Fr	0	0	0	0	0	0	++	+	++	
15. Xanthoproteic test	FCa	Fr	0	0	0	0	0	0	++	0	++	
16. Sakaguchi's test	FCa	Fr	0	0	0	0	0	0	++	+	++	
17. Schultze's test	FCa	Fr	0	0	0	0	0	0	+	0	++	
18. Sudan Black B in 70% alcohal	FCa	Fr	+	0	+++	++	0	0	+++	0	+++	(see Pl. 2, figs. 1-3).

0 = Negative ;   + = Positive ;   ++ = More positive :   +++ = Most positive

C = Carnoy ;   FCa = Formol Calcium :   Fr = Frozen section :   P = Paraffin.

EXPLANATION OF DIAGRAMS

MAGNIFICATION

All the diagrams were drawn with a Camera Lucida at table level using 12·5X eye piece and 100X oil immersion objective.

ABBREVIATIONS

A, Acrosome ; Ac, Acroblast ; Ag, Acrosomic granule ; Av, Acrosomic vesicle ; Bg, Black granules ; Ds, Diffused black stain ; Gb, Golgi body ; Mn, Mitochondrial nebenkern ; N, Nucleus ; Pl, Plate ; Fig., Figure

PLATE 1

Figs. 1-9. L. S. of the male germ cells of *Lygaus hoepes*, fixed in cold carnoy and stained with PAS procedure, counterstained with methyl green or fast green.

Fig. 1. Spermatocyte showing the red coloured internum of the Golgi bodies.

Fig. 2. Young spermatid showing the red acroblast with the deep red acrosomic granule in the angle of the nucleus and the nebenkern.

Fig. 3. Spermatid showing the movement of acroblast towards the anterior end of the nucleus. The nebenkern assumes the onion pattern.

Fig. 4. Spermatid with the acroblast and the acrosomic granule at the anterior end of the nucleus

Figs. 5 & 6. Spermatids with the posteriorly migrated acroblast, the acrosomic granules enlarging.

Fig. 7. Spermatid with the red circular acrosome to which is attached the faintly coloured acroblast.

Figt. 8 & 9. Successive stages in the elongation of the nuclei of the sperms along with the elongation of the acrosomes.

Fig. 10. Section of the spermatocyte, fixed in Ludford's modification of Mann-Kopsch showing duplex structure of Golgi bodies.

Fig. 11. Young spermatid showing the acroblast in the angle of the nucleus and the nebenkern F.W.A.-Iron haematoxylin.

Fig. 12. Spermatid with the acroblast at the anterior end of the nucleus showing the acrosomic granule and the onion-pattern of the nebenkern-F W.A.-Iron haematoxylin.

PLATE 2

Fig. 13. Spermatocyte showing diffused stain round the nucleus with a number of black granules and spheres—Formal calcium frozen sections, Sudan Black B in 70% alcohol.

Figs. 14 & 15. Spermatids showing the black colour in the shell of the acroblast and in the nebenkern Fca-Sudan Black B.

Fig. 16. Spermatocyte showing the blue colour in the externum of the Golgi bodies-Carnoy-Hg/BPB.

Fig. 17. Spermatid showing the blue colour in the elongated nebenkern halves and in the shell of the acroblast-Carnoy-Hg/BPB.

PLATE 1
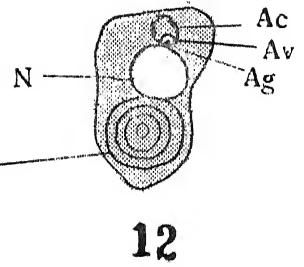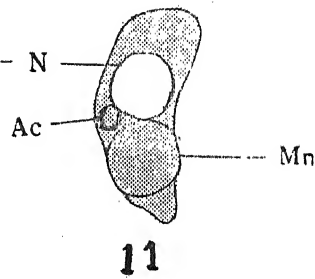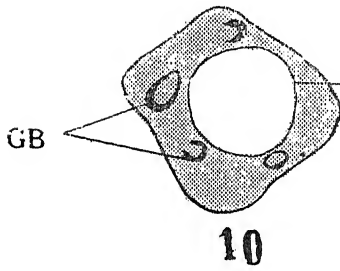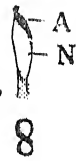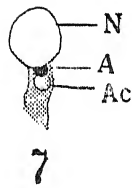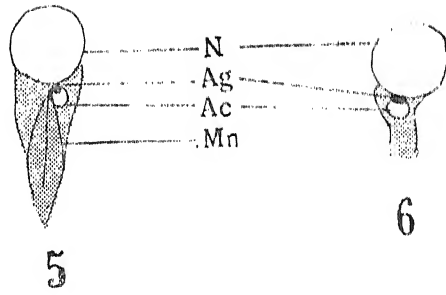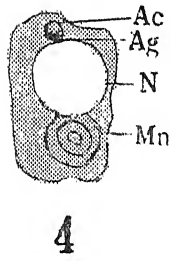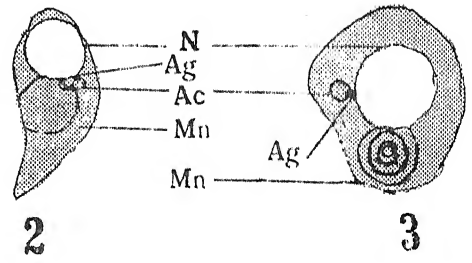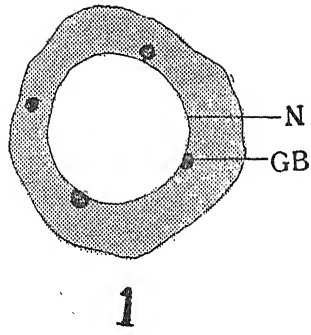
PLATE 2
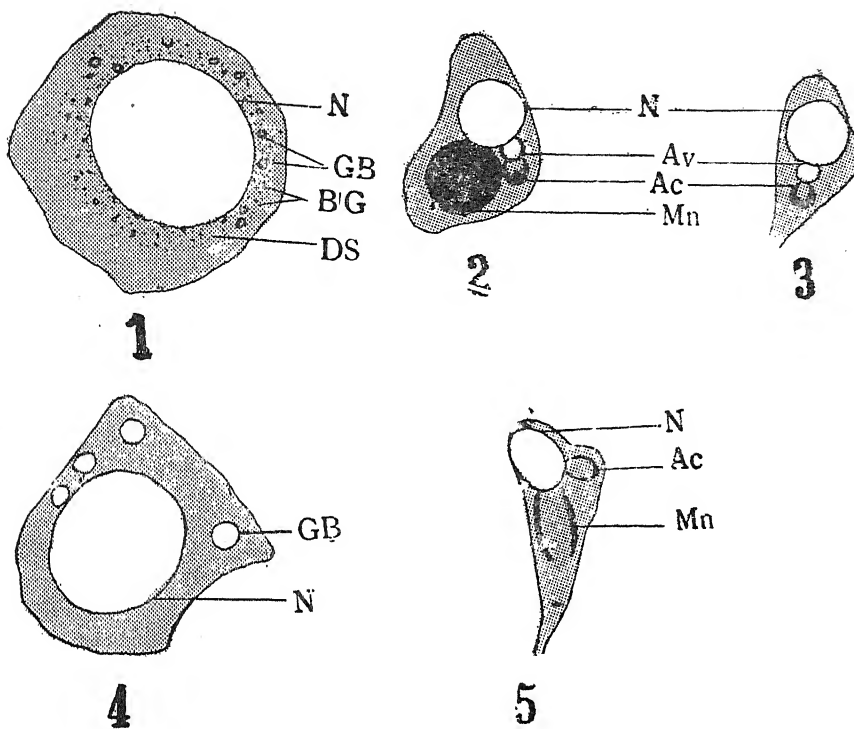
Discussion

The observations on the male germ cells with the PAS technique and subsequent tests reveal that the Golgi internum, the acroblast, the acrosomic granule and the acrosome contain a non-sulphated neutral mucopolysaccharide and lend support to the findings of Schrader and Leuchtenberger (1951), Bawa (1960), Gupta *et al.* (1960). The externum of the Golgi bodies or the shell of the acroblast did not respond to the PAS test as shown by Gupta *et al.* (1960) in *Dysdercus* and *Laccotrephes* and by Bawa (1960) in *Thermobia*. The acroblast internum did not show any spherules or rods by PAS or even in Sudan Black B or Mercuric bromophenol blue preparations as reported by Gupta *et al.* in *Dysdercus* (1960).

Since Gersh (1949) in somatic cells, Schrader and Leuchtenberger (1951) in male germ cells, and Gupta *et al.* (1960) in *Dysdercus* spermatogenesis have demonstrated the presence of protein also in the Golgi bodies, the male germ cells of *Lygaeus* were also subjected to Millon's test, ninhydrin test, Mercuric-bromophenol blue test. In all these tests the acrosome and in the Mercuric bromophenol blue test the Golgi externum also gave a positive reaction indicating the presence of some or the other component of protein.

As far as mitochondria were concerned it was found that they are devoid of any form of polysaccharide contrary to the findings of Bawa (1960) who has shown its presence in the nebenkern. The mitochondria are found to be rich in protein as reported earlier by several workers.

The author's observations with Sudan Black B lend support to the fact that the mitochondria and a part at least of the Golgi bodies consist of some form of lipoid.

Conclusion

It is, therefore, apparent that the Golgi bodies belong to a category of cytoplasmic inclusions different from that of the mitochondria.

Summary

A neutral, nonsulphated mucopolysaccharide was detected in the Golgi internum of the primary spermatocytes and also in the acroblasts and the acrosomes of the early and late spermatids respectively. The PAS reactive substance of the acrosome showed the presence of protein also, so firmly united with it that a pepsin solution of the strength 1% was unable to split them. The PAS reaction was negative in the mitochondria of the spermatocytes and in the nebenkern of the spermatid. The protein found in the mitochondria and in the nepenkern was in a higher concentration than that found in the acrosome and was easily digested with the pepsin solution employed. No lipid was detected in the Golgi internum and in the acrosome, but the Golgi externum, the shell of the acroblast and the mitochondria and the nebenkern showed the presence of lipid.

Hence these two categories of the cytoplasmic inclusions of the developing male germ cells, namely, the Golgi bodies and the mitochondia are cytochemically different.

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UTILIZATION OF POLYSACCHARIDES BY SOME ANTHRACNOSE FUNGI*

By

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[Received on 28th April, 1966]

Polysaccharides occur in higber plants in many forms and hence they play important role in the nutrition of pathogenic fungi. Cellulose and other 'structural' polysaccharides have usually been found to be useless for the nutrition of pathogenic fungi. 'Reserve' polysaccharides are usually available to most of these pathogens, although the rate with which they are utilized depends greatly on the nature and the structural configuration of these carbohydrates as well as on the organism concerned. A number of investigations have been undertaken by various workers to assess the value of these carbohydrates in the carbon nutrition of fungi, but detailed studies on the pathway of utilization of these carbohydrates by fungi have started only recently. In this field some useful contributions have been made by Tandon and Bilgrami (1959) ; Kumar (1961) ; Bilgrami (1962) and Agnihotri (1962, 1963) ; but so far no study ot this kind has been undertaken with the anthracnose fungi responsible for the decay of common fruits. In the present investigation, therefore, the rate of utilization of some common polysaccharides by four anthracnose fungi has been ascertained. Simultaneously, an attempt has also been made to trace the pathway of utilization of these carbohydrates by such organisms.

Materials and Methods

Single-spore cultures of *Colletotrichum gloeosporioides* Penz., *Colletotrichum papayae* P. Henn., *Gloeosporium psidii* Delacr. and *Gloeosporium musarum* Cooke *et* Mass. isolated from diseased fruits of mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and banana (*Musa paradisiaca* L.) respectively, were employed. The basal medium consisted of KNO_3, 3·5g ; KH_2PO_4, 1·75g ; $MgSO_4.7H_2O$, 0·75g ; and distilled water, 1000 ml. To this medium 10g of each polysaccharide was added singly. Four polysaccharides, *viz.*, starch (soluble), dextrin, glycogen and inulin, were used. Pure chemicals supplied by E. Merck and British Drug House were used throughout the investigation. On the basis of previous experimentation the initial pH of the medium was adjusted to 5·8 in all cases. 25 ml of the medium was apportioned in each of the 150 ml Pyrex Erlenmeyer flasks. The media contained in these flasks were then subjected to fractional sterilization. This was accomplished by subjecting the flasks to 30 minutes of steaming for three consecutive days. The flasks were then inoculated with mycelial bits of approximately equal size from ten day old cultures of the respective organisms and were incubated at $25\pm1°C$. For the detection of the hydrolytic products each day 0·01 ml of the medium from a flask belonging to a particular set was analysed by the circular paper chromatographic technique

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recommended by Ranjan *et al.* (1955). The running solvent was *n*-butanol-acetic acid–water (4 : 1 : 5, upper phase) and the spray reagent used was aniline-diphenylamine phosphate (5 vols. 4% aniline, 5 vols. 4% diphenylamine and 1 vol. orthophosphoric acid ; Buchan and Savage, 1952). Reference spots of known sugars were simultaneously run in the same chromatogram to facilitate identification. After spraying the bands of sugars were developed by heating the chromatograms in an electrical oven at 110°C for 90 seconds. Iodine reagent was used for the detection of starch, dextrin and glycogen in the culture medium. This reagent was prepared in the following way : 200 mg of iodine and 400 mg of KI were dissolved in 50 ml of 50% ethyl alcohol and subsequently the final volume was raised to 100 ml by adding distilled water. 2 ml of the culture filtrate was poured in a test tube 1 cm in diameter and to this 1 ml of iodine reagent was added. For a blank comparision 2 ml of distilled water was taken in another similar tube and 1 ml of iodine reagent was added to this. When the colour of the solution in the first tube was noticeably darker than that of the solution in the second tube the presence of polysaccharide was indicated. For the detection of inulin duplicate chromatograms were run in the above solvent. Then the area of paper chromatogram in which the spot of the culture filtrate was originally kept (start) was cut as circular disc 1 cm in diameter. Each of such discs was boiled for 5 minutes in 1 ml of distilled water. The paper piece was then removed and 1 ml of 2 N HCl was added. This solution was autoclaved at 20 lbs pressure for 30 minutes, evaporated to dryness on a water bath and subsequently the volume was made upto 0·5 ml by adding distilled water. The whole quantity of this solution was spotted on a chromatogram which was run and developed as usual. Appearance of fructose on this chromatogram indicated the presence of inulin.

Simultaneously, in each case the mycelial mats were harvested after 5, 10 and 15 days of incubation. Previously dried and weighed Whatman No. 42 filter papers were used for this purpose. They were dried to constant weight in an electrical oven at 60–62°C and weighed again after cooling. The average dry weight of the mycelium was taken as the criterion for growth. The pH of the medium was also recorded after the same intervals with the help of B. D. H. pH indicator papers. All the experiments were conducted in triplicates.

Results

Utilization of starch : It was observed that starch was readily hydrolysed by all the anthracnose fungi under study. The hydrolytic product glucose was detected in the medium during the utilization of this polysaccharide. Maltose also made its appearance in the medium used by *Gloeosporium musarum* and *Colletotrichum papayae*. In case of the last named organism an additional oligosaccharide (Rf. 0·18) could also be detected. The hydrolytic products were used up by all these fungi, except *G. musarum*, before the end of the experiment (15 days). In case of *G. musarum* a small quantity of glucose (as evidenced by the intensity of the band on the chromatogram) could be traced at the end of 15 days of incubation. Starch supported good growth of all these organisms. A steady increase in the mycelial dry weight of these fungi was recorded. The pH of the medium showed a gradual upward drift finally reaching neutrality or slight alkalinity.

Utilization of dextrin : Dextrin was hydrolysed by all the anthracnose fungi included in the present study. Glucose appeared after 7 and 6 days of incubation

in the medium used by *Colletotrichum gloeosporioides* and *Gloeosporium psidii* respectively. In case of these two organisms no other hydrolytic product could be detected. *C. papayae* and *G. musarum* showed the appearance of maltose and one more oligosaccharide (Rf. 0·18) in the culture medium. The dry weight of mycelium showed a gradual increase in all cases. The pH drift was towards neutrality or slight alkalinity.

Utilization of glycogen : Out of the four anthracnose fungi only *C. gloeosporioides* was unable to utilize glycogen satisfactorily. Glucose was detected in the medium during the growth of *C. papayae*, *G. psidii* and *G. musarum*. These three organisms completely hydrolysed glycogen before the end of the incubation period of 15 days. In case of *C. gloeosporioides* glycogen persisted in the culture medium till the end of the experimental period (15 days) and no glucose could be traced at any stage of incubation. Growth attainment of the last named fungus was also very poor, whereas the growth was fairly good for the rest of the organisms. The pH of the medium showed a gradual increase as the incubation progressed. This drift was comparatively slower in the medium during the growth of *C. gloeosporioides* and the final pH recorded was 6·2. In case of the other fungi the final pH of the medium ranged from 7·2 to 7·6.

Utilization of inulin : *C. papayae* and *G. psidii* utilized inulin poorly. Inulin persisted in the culture medium used by both these fungi till the end of the experiment and no hydrolytic product could be detected. The mycelial dry weights recorded were also quite poor as compared to those obtained on other polysaccharides. *C. gloeosporioides* made a better utilization of inulin. In that case this polysaccharide persisted in the medium upto 14 days. Fructose and one oligosaccharide (Rf 0·35) appeared in the culture medium. *G. musarum* could not bring about complete hydrolysis of inulin within the incubation period of 15 days. The quantity of residual inulin was, however, small. Fructose and two oligosaccharides (Rf 0·35 and 0·20) appeared in the culture medium during the utilization of inulin by *G. musarum*. The pH of the medium used by all these four fungi showed a gradual rise, but this drift was comparatively slow.

The details of the results obtained have been summarized in Tables 1 and 2.

TABLE I

The presence (in days) of various carbohydrates in the culture medium during the utilization of different polysaccharides by the four anthracnose fungi

Carbohydrate	Rf	C. gloeosporioides	C. papayae	G. psidii	G. musarum
STARCH		0–12	0–10	0–13	0–13
Glucose	0·47	4–14	2–12	4–14	4–15
Maltose	0·26	–	6–9	–	9–11
Oligosaccharide	0·18	–	6–8	–.	–
DEXTRIN		0–14	0–12	0–14	0–15
Glucose	0·47	7–15	2–12	6–14	2–15
Maltose	0·26	–	3–6	–	3–12
Oligosaccharide	0·18	–	3–4	–	4–10

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Carbohydrate	Rf	C. gloeosporioides	C. papayae	G. psidii	G. musarum
GLYCOGEN		0–15	0–11	0–10	0–13
Glucose	0·47	–	4–11	5–9	4–14
INULIN		0–14	0–15	0–15	0–15
Fructose	0·51	3–14	–	–	2–15
Oligosaccharide I	0·35	3–6	–	–	3–6
Oligosaccharide II	0·20	–	–	–	3–4

TABLE 2

The dry weights of mycelium and pH of the culture medium of the four anthracnose fungi during their growth on different polysaccharides

Polysaccharide	Days of incubation	C. gloeosporioides		C. papayae		G. psidii		G. musarum	
		Dry wt. in mg	pH	Dry wt. in mg	pH	Dry wt. in mg	pH	Dry wt. in mg	pH
STARCH	5	19·7	5·8	30·9	5·9	23·5	5·8	12·8	5·8
	10	59·3	6·0	78·3	6·4	87·5	6·2	44·2	6·0
	15	85·1	7·0	91·9	7·3	108·7	7·1	71·5	7·0
DEXTRIN	5	16·3	5·8	30·0	5·9	18·7	5·8	16·0	5·8
	10	56·1	6·1	85·0	6·5	75·3	6·0	48·0	6·0
	15	80·9	7·1	95·6	7·4	102·0	7·1	70·5	7·1
GLYCOGEN	5	5·0	5·8	33·8	5·9	35·6	5·9	19·8	5·8
	10	15·9	5·9	64·0	6·2	88·7	6·1	49·6	6·1
	15	20·7	6·2	83·4	7·6	109·5	7·4	64·6	7·2
INULIN	5	10·7	5·8	6·7	5·8	5·8	5·8	7·1	5·8
	10	49·0	6·0	33·3	5·9	25·1	5·9	25·6	5·9
	15	61·9	6·9	44·4	6·2	32·5	6·1	53·1	6·2

Discussions and Conclusions

Polysaccharides are complex carbohydrates containing a large number of monosaccharide residues. The ability of an organism to utilize a polysaccharide depends upon its capacity to convert these complex carbohydrates into soluble sugars of low molecular weight. The efficiency with which fungi utilize polysaccharides, therefore, depends upon their capability of producing suitable hydrolytic enzymes.

Starch, the universal reserve carbohydrate of green plants, is composed of glucose residues joined through α-glycosidic linkages. The enzymatic hydrolysis of starch may be expressed schematically as follows :

$$\text{Starch} \rightarrow \text{dextrin} \rightarrow \text{maltose} \rightarrow \text{D-glucose.}$$
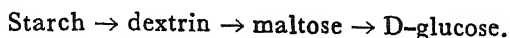
Two enzyme systems are operative in bringing about the completion of this conversion : (1) amylases (diastases) which act upon starch resulting in the liberation of maltose and (2) α-glycosidases which convert maltose into glucose. In the present study the appearance of glucose in the culture medium during the utilization of starch is an evidence that this polysaccharide was utilized through a hydrolytic pathway. Non-appearance of maltose in cases of *Colletotrichum gloeosporioides* and *Gloeosporium psidii* was apparently due to slower rate of liberation and at the same time rapid rate of breakdown of this sugar. Tandon and Bilgrami (1959) demonstrated the formation of glucose, maltose and two other oligosaccharides during the utilization of starch by two species of *Phyllosticta*. Later on Agnihotri (1963) working with four species of *Aspergillus* also obtained similar results. Ghosh (1964) reported that the isolates of *Colletotrichum gloeosporioides* and *C. dematium* studied by him did not show the formation of maltose in the culture medium during the utilization of starch, although glucose made its appearance in all cases. The isolate of *C. gloeosporioides* included in the present investigation also exhibited similar behaviour. The isolate of *C. gloeosporioides* studied by Prasad (1965) showed an early appearance of maltose in the culture medium and in this respect it differed from the present isolate.

Dextrin, a product of partial hydrolysis of starch, is also acted upon by amylase. Unlike starch which is hydrolysed by both α and β amylases, dextrin is attacked only by α amylase on account of the presence of C_1—C_6 linkages. The results of the present investigation show that the utilization of dextrin by the four anthracnose fungi closely resembled that of starch. The only major difference was the appearance of one more oligosaccharide in the medium used by *Gloeosporium musarum*. Agnihotri (1962, 1963) has also observed that the pathway of utilization of dextrin by some species of *Aspergillus* resembled that of starch.

Glycogen, a polymer of glucose, occurs as reserved carbohydrate in animal tissues and in some fungi. This polysaccharide is also hydrolysed by amylase. In the present study glucose could be traced in the medium during the utilization of glycogen by all these anthracnose fungi, except *Colletotrichum gloeosporioides*. No other intermediate product could be detected in any case. The species of *Aspergillus* studied by Agnihotri (1963), however, showed the appearance of glucose and one to two oligosaccharides.

Inulin, a fructose containing polysaccharide, occurs in some higher plants. It is believed that inulin consists of a sucrose unit linked with a large number of fructose residues. It is, therefore, expected that inulin would yield fructose and a small quantity of glucose on complete hydrolysis. The results obtained by Agnihotri (1963) indicated that during the utilization of inulin by four species of *Aspergillus* no glucose could be traced in any case, but fructose and as many as seven oligosaccharides made their appearance in the culture medium. In the present investigation also glucose could not be detected, although the presence of fructose and oligosaccharide in the culture medium used by *Colletotrichum gloeosporioides* and *Gloeosporium musarum* indicated that hydrolysis of inulin took place. This is not unexpected when due consideration is given to the facts that the rate of hydrolysis of inulin was slow and the quantity of glucose present in inulin was proportionately very small. Poor growth of *Colletotrichum papayae*

and *Gloeosporium psidii* on inulin and non-appearance of any of the hydrolytic products in the culture medium was probably due to the inability of these organisms to produce an adequate amount of inulase.

It could be concluded from the present studies that the four anthracnose fungi converted these complex carbohydrates to simpler sugars prior to utilization. Only during the utilization of glycogen by *Colletotrichum gloeosporioides* and inulin by *C. papayae* and *Gloeosporium psidii* no hydrolytic product was detected; but in those cases also the growth rate was slow and it was not unlikely that there was slow hydrolysis and simultaneous utilization of the hydrolytic products. The poor rate of utilization of these polysaccharides was obviously due to poor amylase or inulase activity. This view is supported by the results of some previous investigations employing the present organisms (Ghosh *et al.*, 1965; Singh *et al.*, 1965) which indicated that the end products of hydrolysis of these polysaccharides, *viz.*, glucose and fructose, or the intermediate product maltose were readily utilized. It can be pointed out that in some cases growth appeared on these polysaccharides before any hydrolytic product appeared in the culture medium. This also appears to be due to simultaneous utilization of the hydrolytic products, since direct utilization of these complex carbohydrates was improbable on account of their high molecular weights.

Summary

Utilization of four polysaccharides, *viz.*, starch, dextrin, glycogen and inulin, by *Colletotrichum gloeosporioides*, *C. papayae*, *Gloeosporium psidii* and *G. musarum* isolated from diseased fruits of mango, papaya, guava and banana respectively, was studied chromatographically. Starch was completely hydrolysed by all these organisms within the incubation period (15 days). During the utilization of starch and dextrin, glucose appeared in the medium in all cases, whereas another hydrolytic product, maltose, could only be detected in the culture medium used by *C. papayae* and *G. musarum*. One more oligosaccharide (Rf 0·18) made its appearance in course of utilization of dextrin by the two last named organisms. This oligosaccharide could also be traced in the medium of *C. papayae* during its growth on starch. Good growth of all these organisms was obtained on starch and dextrin. Glucose appeared in the medium during the utilization of glycogen by all these fungi, except *C. gloeosporioides*. The growth of the last named organism on glycogen was also poor. *C. papayae* and *G. psidii* made a poor growth on inulin and none of the hydrolytic products could be detected. Fair utilization of inulin by *C. gloeosporioides* and *G. musarum* was observed. Fructose and one oligosaccharide (Rf 0·35) appeared in the medium in case of the first organism, while in the medium of the last named fungus in addition to fructose and this oligosaccharide (Rf 0·35) a second oligosaccharide (Rf 0·20) could also be detected. In all cases the mycelial dry weight showed an increase upto the end of the incubation period of 15 days. In most of the cases the pH of the medium recorded an upward drift, and finally reached neutrality or slight alkalinity.

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ON AN ECHINOSTOME CERCARIA *CERCARIA MAINPURENSIS*, N.SP. FROM MAINPURI, UTTAR PRADESH (INDIA)

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Cercaria mainpurensis, n.sp.

Out of 12 specimens of the snail, *Endoplanorbis exustus*, collected from a tank in district Mainpuri, U.P. five were found liberating an echinostome cercaria which is described below as a new species.

The cercariae emerge from snail host during morning. They swim by the wriggling movements of their tails. While swimming, they pause off, settle to the bottom of the container, and crawl a while and then again swim up. They are positively phototropic as they are found to crawl towards the source of illumination.

Body (fig. 1) large, aspinose, elongate-oval with a slightly narrow and blunt anterior end and a broad, round posterior end, measuring $0.25 - 0.32 \times 0.12 - 0.15$ mm. in live specimens while $0.19 - 0.23 \times 0.07 - 0.09$ mm. in fixed specimens. Tail is aspinose with an invaginable caudal process at its tip. It is larger than the body and measures $0.30 - 0.39$ mm. in length in live and $0.32 - 0.40$ mm. in length in fixed specimens. Dorsal fin fold is present roughly at the last quarter of the tail and extends up to the middle of the caudal process. Ventral fin fold is, however, absent. A large number of round nuclei approximately 63 in number, are found in the tail parenchyma.

Oral sucker terminal in position and circular in outline, measures 0.03×0.03 mm. in live and 0.03×0.03 mm. in fixed specimens. Ventral sucker larger than the oral sucker, situated in the posterior half of the body and measures $0.04 - 0.05$ mm. in diameter in live and 0.05×0.05 mm. in fixed specimens. Cephalic collar (fig. 2) is prominent and armed with 48 spines, seems to be arranged in single row. The four spines of the end group are larger than the remaining spines. Two closely just opposed masses of spherical granules are present at the entrance of prepharynx which is short measuring $0.03 - 0.04$ mm. in length. Pharynx is globular or oval and measures $0.04 - 0.07 \times 0.03 - 0.04$ mm. Oesophagus is quite long and measures $0.07 - 0.08$ mm. in length. It bifurcates, a short distance in front of the ventral sucker into intestinal caeca which extends almost upto the posterior end of the body.

Three pairs of lobate penetration glands (fig. 1) are present, one behind the other, at the sides of the oesophagus; each gland contains a nucleus and fine granules which stain light with neutral red and nile blue. Fine ductules of these glands of each side run together anteriorly and open outside by separate pores close to the anterior border of the oral sucker. Cystogenus gland cells are present in the whole body. They contain bacilli-form bodies arranged in a parallel way in each cell. A mass of gland cell is present at the origin of the tail.

2

0.2 mm.

1

3
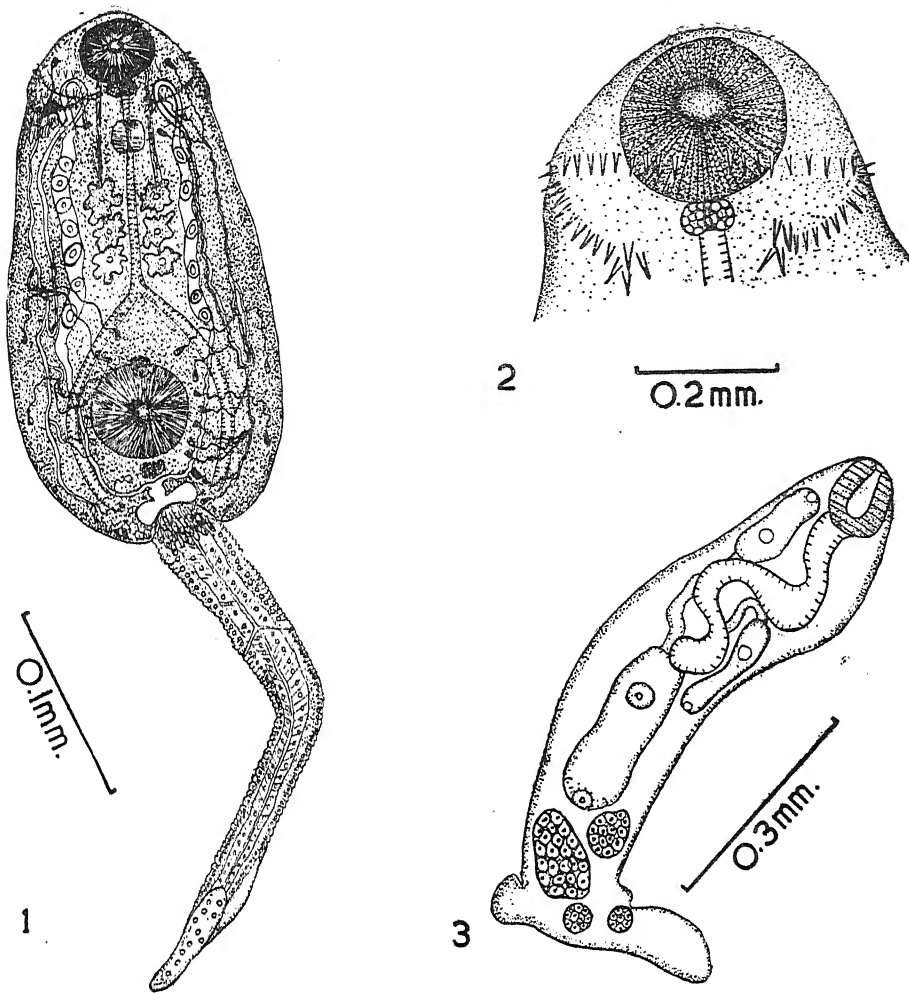
Fig. 1. *Cercaria mainpurensis* n.sp. (drawn from a live specimen).
Fig. 2. *Cercaria mainpurensis* n.sp. Head collar showing spines (drawn from a live specimen).
Fig. 3. *Cercaria mainpurensis* n.sp. Redia with cercaria (drawn from a live specimen).

The gonads (fig. 1) are represented by two round masses of cells present one at the anterior and the other at the posterior border of the ventral sucker.

The excretory system (fig. 1) is of echinostome type. The excretory bladder is a transversely elongated structure located at the hind end of the body. Two excretory ducts join to form a small chamber (called secondary chamber by some workers) which open into the anterior side of the excretory bladder, there being a constriction between the two. Each excretory duct runs anteriorly as the ascending limp upto the level of the oral sucker, where it forms a loop and turns back as roughly upto the middle region of the body, where the duct divides into an anterior branch called secondary ascending collecting tubule and a posterior branch, called a secondary descending tubule. The ascending tubule is much dilated as it

contains globular refractile granules of different sizes, numbering 6 or 7. The anterior collecting tubule is connected with the capillaries of 3 flame cells and it has a tertiary branch, which receives capillary tubules of 3 flame cells. Similarly the posterior collecting tubule terminates in the capillaries of 3 flame cells and it receives two tertiary branches each connected with the capillaries of 3 flame cells. Thus the flame cells are arranged in triples and the flame cell formula is 2 (3+3) + 2 (3+3+3). A caudal excretory canal extends into the tail from the posterior side of the excretory vesicle and runs upto the base of the caudal process. A pair of lateral tubules arise from the caudal excretory tubule about one-third of its length inclusive of the caudal process. These tubules run outwards and backwards to open outside by pores located 0·01 mm. from the base of the tail.

On crushing the infected snails rediae were recovered from the digestive gland. The young rediae are large, elongated and golden yellow. These rediae perform movements of contraction and expansion. The collar is present about 0·3 – 0·9 mm. from the anterior end of the body and behind it the birth pore is present on one side. Towards the posterior end of the body, about 0·3 – 0·7 in front of the hind end, are present two short ambulatory processes. Mouth terminal and leads into a muscular pharynx measuring 0·05 – 0·08 mm. × 0·03 – 0·04 mm. Pharynx is followed by a fairly long rhabdocoel gut which extends behind to a point about 0·06 – 0·17 mm. in front of the ambulatory processes. The gut in the older rediae appears short and contains blackish material but in young developing rediae (fig. 3), it appears quite long. Few well-developed cercariae, 1–4 in number, are present in each rediae besides others which are in various developmental stages. Several germ cells and germ balls are also found in the rediae.

Encysted matacercariae were also obtained from the digestive gland and the mantle of the snail host. The cyst are round to oval transparent and double walled.

Discussion

The cercaria belongs to "Echinatoides" group of Sewell (1922). Of all the cercariae described under this group, it closely resembles C. nairi Peter, 1955 from which it can be distinguished by ratio of its oral and ventral suckers, by its lobate penetration glands, by the presence of caudal mass of glands, and by the number of collar spines.

The cercaria is, therefore, considered to be a new species.

Acknowledgements

The writer is thankful to Dr. S. C. Baugh, Department of Zoology for the guidance and to Professor M. B. Lal, F.N.I., Head, Zoology Department, for the laboratory facilities. Thanks are also due to Government of India, for award of a Research Training Scholarship.

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STUDIES ON FUNGAL DISEASES OF SOME TROPICAL FRUITS VII. EFFECT OF TEMPERATURE ON THE DECAY OF MANGO, BANANA AND GUAVA CAUSED BY SOME IMPORTANT PATHOGENS*

By

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[Received on 28th April, 1966]

Mango, banana and guava are among the commonest tropical fruits widely grown in India. Consequently, the losses incurred by them as a result of fungal decay at various stages of development and storage are of much concern. A large number of fungi have been recorded to be associated with the diseased tissue of these fruits, but comparatively few of them have been shown to be pathogens of significance. Wardlaw (1935) has mentioned that the extent of loss sustained by banana fruits due to fungal invasion in different countries varies considerably. He has also pointed out that the temperature conditions play a prominent role in determining the type of decay which becomes predominant in storage. Srivastava *et al.* (1965) observed that the percentage of mango fruits infected with three common pathogens, *viz.*, *Aspergillus niger*, *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae*, showed great variation at different localities in India. An extensive survey of markets and storage places situated in different States of India undertaken by the present authors has revealed that the magnitude of loss suffered by the fruits of mango, banana and guava due to infection caused by various pathogenic fungi showed great variation. It appears that environmental factors—mainly temperature—were greatly responsible for such variations. In order to gain a proper understanding of the role of temperature on the advancement of fungal decay of fruits in nature it is necessary to artificially infect fruits and make observation under controlled conditions. In the present study representative varieties of mango, banana and guava fruits were artificially inoculated with their respective pathogens. Subsequently, they were stored at different temperatures and the amount of rot produced after a definite interval was determined.

Materials and Methods

Under-ripe fruits of 'Langra' variety of mango (*Mangifera indica* L.), 'Harichal' variety of banana (*Musa paradisiaca* L.) and 'Safeda' variety of guava (*Psidium guajava* L.) were employed. The following pathogens were used for inoculating these fruits : *Colletotrichum gloeosporioides* Penz., *Botryodiplodia theobromae* Pat. and *Aspergillus niger* van Tiegh. for mango ; *Gloeosporium musarum* Cooke et Mass. and *Botryodiplodia theobromae* Pat. for banana ; and *Pestalotia psidii* Pat., *Botryodiplodia theobromae* Pat., *Gloeosporium psidii* Delacr. and *Phoma psidii* P. Henn. for guava. Pure single-spore cultures of these fungi isolated from their respective hosts were employed. Each individual fruit was weighed and its weight was recorded. The fruits were then inoculated with their respective pathogens using Granger and Horne's (1924) method. Subsequently, each fruit was put inside a polyethylene bag and stored at the desired temperature.

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At the end of each incubation period the percentage rot due to each pathogen was calculated. For this, each fruit was reweighed after removing the rotten portion carefully and the percentage rot was calculated with the help of the formula :

$$\text{Percentage rot} = \frac{(W - w) \times 100}{W}$$

where, W = weight of the fruit before infection

and w = weight of the fruit after removal of the infected tissue.

In case of mango the weight of the seed was deducted from the initial weight as well as the final weight obtained after the removal of the diseased tissue, and then the percentage rot was calculated. In control fruits there was no noticeable decrease due to loss of water at 10–20°C. At higher temperatures this decrease was marked. In storage experiments at higher temperatures, therefore, the percentage of the loss due to desiccation was estimated in each case and on this basis adjustments were made while calculating the percentage rot. Each reading was recorded on the basis of 25 replicates.

Observations

Fruits of mango inoculated with the three pathogens did not show any infection at 10°C even after they had been stored for 15 days. There was no rot when fruits inoculated with *Colletotrichum gloeosporioides* and *Aspergillus niger* were incubated at 15°C for 10 days, but some decay was observed after 15 days. In order to find out whether exposure to lower temperature increased susceptibility or resistance of fruits in relation to fungal infection, inoculated fruits were kept at lower temperatures for 10 days. Subsequently, they were brought back to room temperature and advancement of disease after 5 days was recorded. It was observed that an exposure to 10°C for 10 days resulted in an enhancement of the rate of decay caused by *C. gloeosporioides* and *A. niger* when the fruits were brought back to room temperature. In all cases the rate of advancement of the rot caused by *Botryodiplodia theobromae* was markedly higher as compared to the decay due to *C. gloeosporioides* or *A. niger*. The details of the results obtained have been summarized in Table 1.

TABLE 1

Percentage rot of 'Langra' variety of mango fruits inoculated with three common pathogens in storage at different temperatures

Pathogen	Days of incubation	Temperature in °C					
		10	15	20	25	33±2	(Room temp.)
Colletotrichum	10	nil	nil	8·8	12·7	18·9	
gloeosporioides	15	nil	4·8	22·9	40·1	69·0	
	15	12·8	8·0	31·0	–	–	
	(Brought to room temp. after 10 days)						
Botryodiplodia	10	nil	6·5	15·1	25·4	50·3	
theobromae	15	nil	14·8	33·0	49·8	100	
	15	13·0	32·1	58·9	–	–	
	(Brought to room temp. after 10 days)						

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Pathogen	Days of incubation	Temperature in °C				
		10	15	20	25	33±2 (Room temp.)
Aspergillus niger	10	nil	nil	6·3	10·5	29·3
	15	nil	5·2	19·6	34·7	87·2
	15	15·9	16·3	40·0	–	–
	(Brought to room temp. after 10 days)					

Banana fruits were inoculated with *Gloeosporium musarum* and *Botryodiplodia theobromae* and stored at different temperatures. The percentage rot calculated after 4 and 8 days of incubation revealed that the latter organism caused greater loss. At 10°C there was no rot in any case. When the fruits were brought back to room temperature after an exposure to 10°C for 4 days the disease appeared and the progress of the rot caused by *B. theobromae* was more or less similar to usual rot at that temperature. In case of *G. musarum* there was slight retardation in this rate. At 15°C there was no rot upto 4 days of incubation, but after 8 days a small amount of rot was observed. At 20°C the rot appeared early although the rate of advancement was slow. Fruits infected with *B. theobromae* showed very high percentage rot after 8 days of incubation at 25°C and fruits stored for the same period at 30°C and 35°C sustained complete decay. After 8 days of incubation percentage rot due to *G. musarum* at room temperature (25±2°C) was much smaller as compared to that at 30°C or 35°C. The details of the results obtained have been summarized in Table 2.

TABLE 2

Percentage rot of 'Harichal' variety of banana fruits inoculated with two common pathogens in storage at different temperatures

Pathogen	Days of incubation	Temperature in °C					
		10	15	20	25±2 (Room temp.)	30	35
Gloeosporium musarum	4	nil	nil	10·1	14·2	26·3	30·2
	8	nil	3·8	27·7	39·6	74·8	80·3
	8	8·0	12·8	32·5	–	–	–
	(Brought to room temp. after 4 days)						
Botryodiplodia theobromae	4	nil	nil	16·4	24·9	39·7	49·7
	8	nil	9·2	48·8	88·8	100	100
	8	22·2	25·0	72·6	–	–	–
	(Brought to room temp. after 4 days)						

Guava fruits inoculated with *Pestalotia psidii*, *Botryodiplodia theobromae*, *Gloeosporium psidii* and *Phoma psidii* were similarly stored at different temperatures. The results obtained indicated that at 10°C there was no rot, but after incubation at this temperature the rate of decay was rapid when the fruits were brought back to room temperature (25±2°C). Only fruits inoculated with *Phoma psidii* showed very slight decay after 10 days of incubation at 15°C. In all other cases no rot was observed at that temperature. When fruits exposed to such condition were brought to room temperature there was no enhancement of decay in any case. The decay was slow at 20°C although the rot made its appearance in all cases. After 10 days of incubation at 25±2°C the percentage rot was high in case of infection with *B. theobromae* and *Phoma psidii*, whereas the same was comparatively lower for the fruits infected with *G. psidii* and *Pestalotia psidii*. In all cases the rot was maximum at 30°C. The advancement of rot caused by all the four organisms was retarded at 35°C, but at that temperature the fruits shrivelled up, their pulp became brownish and they were rendered unsuitable for consumption. The percentage rot observed at different temperatures has been shown in Table 3.

TABLE 3

Percentage rot of 'Safeda' variety of guava fruits inoculated with four common pathogens in storage at different temperatures

Pathogen	Days of incubation	Temperature in °C					
		10	15	20	25±2 (Room temp.)	30	35
Pestalotia	5	nil	nil	nil	6·9	10·2	nil
psidii	10	nil	nil	13·0	19·1	25·4	5·1
	10	12·3	7·9	8·4	—	—	—
	(Brought to room temp. after 5 days).						
Botryodiplodia	5	nil	nil	nil	19·6	19·9	4·6
theobromae	10	nil	nil	26·9	83·3	84·6	14·9
	10	18·8	16·8	37·5	—	—	—
	(Brought to room temp. after 5 days).						
Gloeosoporium	5	nil	nil	nil	6·8	8·5	nil
psidii	10	nil	nil	9·8	24·9	28 9	6·7
	10	13·5	7·0	10·7	—	—	—
	(Brought to room temp. after 5 days).						
Phoma psidii	5	nil	nil	9·6	21·5	29·7	7·5
	10	nil	2·9	42·5	82·7	100	25·8
	10	36·1	23·1	61·1	—	—	—
	(Brought to room temp. after 5 days)						

Discussions and Conclusions

Temperature plays a vital role in the life of fungi. The growth of these organisms is greatly influenced by temperature. It, therefore, is quite natural to presume that advancement of a pathogenic fungus inside host tissue would be greatly affected by the temperature of its environment. It is apparent from the results of the present study that the temperature at which the fruits were stored had a pronounced effect on the rate of advancement of decay and consequently on the magnitude of the loss incurred by them due to fungal infection. This advancement of a fungus inside the host tissue is, in fact, a very much complicated process being the net result of the interaction between the host and the pathogen. Temperature, therefore, would not only have a direct influence on the growth of the fungus but it would also affect fungal advancement indirectly by increasing or minimizing resistance of the host.

Lower temperature retards the rate of metabolism in living organisms. Such temperature, therefore, minimizes loss due to fungal infection in two ways. Firstly, it delays the advent of senescence and consequent decrease in resistance in fruits ; secondly, it slows down the rate of advancement of the pathogen. In the present investigation it was observed that at 10°C decay of banana caused by *Botryodiplodia theobromae* and *Gloeosporium musarum* could be prevented. After an exposure to this temperature when the fruits were brought back to room temperature the rot appeared was not more than that was usual at the latter temperature. In case of fruits inoculated with *G. musarum* there was even slight retardation in the rate of decay. This might be due to the fact that either this low temperature produced a lag effect on the growth of the pathogen or storage at this temperature provided the fruits a better resistance. Wardlaw and McGuire (1931) had found that a temperature of 53°F (11·7°C) was very suitable for minimizing loss due to fungal infection in 'Gros Michel' variety of banana. Williamson (1964) has also recommended low temperature (10°C) for prevention of *Botryodiplodia* rot of 'Bhusaval' variety of banana. In case of mango and guava fruits also 10°C was found to check fungal decay ; but when fruits exposed to this temperature were transferred to room temperature the rate of decay caused by all the organisms, except *B. theobromae*, was more or less enhanced. This was obviously due to decrease in resistance as a result of exposure to such low temperature. This is interesting, because it is usual practice to store mangoes at about 10°C or even at slightly lower temperature (Banerjee and Rao, 1933 ; Wardlaw and Leonard, 1936 ; Cheema *et al.*, 1939 ; Karmakar and Joshi, 1940 ; Mukerjee, 1961). In the present study this enhancement in the rate of fungal decay after an exposure to 10°C appears to be due to the fact that the variety of mango employed ('Langra') was more easily affected by 'chilling' as pointed out by Singh *et al.* (1963).

At higher temperatures the rate of decay was high in mango and banana. In case of guava fruits a temperature of 35°C retarded the growth of pathogens. The fruits, however, showed a rapid degeneration at this temperature and hence it cannot be recommended for storage.

It can safely be concluded from the present study that a temperature of 15°C would be suitable for storing the fruits of mango and guava because it did not decrease disease resistance and even in cases where there was fungal decay the rate of advancement of disease was very slow. 10°C would be suitable for storing banana. The optimum temperature which would minimize loss due to fungal decay to bare minimum and at the same time would not cause chill effect

on fruits should, however, vary with the variety of fruits as well as with the pathogen concerned. Detailed investigations on these lines are in progress.

Summary

Fruits of mango were inoculated with *Colletotrichum gloeosporioides*, *Botryodiplodia theobromae* and *Aspergillus niger* ; banana with *Gloeosporium musarum* and *Botryodiplodia theobromae* ; and guava with *Pestalotia psidii*, *Botryodiplodia theobromae*, *Gloeosporium psidii* and *Phoma psidii* and stored at different temperatures. Percentage rot caused by these organisms was estimated at two intervals. Storage at 10^0C prevented decay in all cases. When mango and guava were exposed to 10^0C and brought back to room temperature the rate of decay was enhanced. There was a very little amount of rot in mango and banana at 15^0C. In guava out of the four pathogens only *Phoma psidii* could cause slight decay at this temperature. *Botryodiplodia theobromae* caused greatest loss in all cases. Higher temperatures favoured fungal decay. Though the advance nent of rot of guava caused by fungi was retarded at 35^0C, the fruits turned brown, shrivelled up and became unsuitable for consumption.

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THE ACTIVITY OF THE NEUROSECRETORY CELLS OF *PERIPLANETA AMERICANA* IN RELATION TO OVARIAN CYCLE

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Introduction

Very little is known yet about the functions of the neurosecretory cells in adult insects. Scharrer (1941) believed that neurosecretory cells in the pars intercerebralis of the brain control certain aspects of metabolism and Thomsen (1948) regarded that they also influence egg production. These conclusions have been arrived at on the basis of the correlation observed between the activity of these cells and the ovarian cycle. However, not only very few studies of this kind have been conducted, the problem has become further complicated by the discovery of neurosecretory cells in parts of the brain other than the pars intercerebralis, in the suboesophageal ganglion (Scharrer, 1941) and also in the thoracic and abdominal ganglia of several insects (Geldiay, 1959 ; Gersch, 1959). In *Periplaneta americana*, the presence of neurosecretory cells in all the ganglia has been observed by Gersch (1959) and the present workers (unpublished) and in the present work, a study has been made of the activity of these cells in the various ganglia in relation to the ovarian activity. The former has been observed in terms of the size of the cells and their nuclei, the state of the cytoplasm, as well as the presence and distribution of RNA which has been found to occur abundantly in the neurosecretory cells, but not in nerve cells, while the latter has been noted in terms of the length of ovarioles and the size of the last ova.

Material and Technique

Female adult specimens of *Periplaneta americana* were used in the present study. Specimens reared in the laboratory with the usual technique were dissected in Insect Ringer's solution, and their ovaries, as well as the entire nervous system, were dissected out in the shortest possible time. On the basis of the development (length) of the ovary (average length of 10 ovarioles) and the last ovum (average length of 10 ova), the specimens were divided into seven stages. The average lengths of the ovarioles and those of the last ova in the successive stages are as follows :

Stage	Length of ovarioles	Length of last ova
First stage	0·8 cm	0·59 mm
Second stage	0·9 cm	2·05 mm
Third stage	1·0 cm	2·21 mm

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Stage	Length of ovarioles	Length of last ova
Fourth stage	1·1 cm	2·27 mm
Fifth stage	1·3 cm	3·25 mm
Sixth stage	1·4 cm	3·08 mm
Seventh stage	1·5 cm	3·30 mm

The ovarioles and the ova were measured fresh while the cells were measured in sections.

After dissecting out the entire nervous system, it was fixed in Bouin's fixative, Carnoy's solution or Heidenhain's Susa's fixative, washed, embedded and sectioned according to the usual procedure. Sections were stained in Gomori's Chrome-alum haematoxylin-phloxin or Heidenhain's Azan stain. The latter also gave very good results.

For the study of nucleic acids, the ganglia were fixed in Heidenhain's mercuric saline and Carnoy's fixative and stained with Methyl green-Pyronin.

In order to be able to study the activity of the same cells, a few prominent cells in characteristic locations in the ganglia concerned were chosen and these were studied from stage to stage.

Since observations on the secretory activity showed that neurosecretory cells of the brain and suboesophageal ganglion are in one cycle and those of the thoracic and abdominal ganglia in another cycle, the study of the nucleic acids was made only in the brain and the thoracic ganglion cells.

Observations

First stage

(A) *Brain.* Although neurosecretory cells occur in many locations, observations were made on the larger, more prominent cells of the pars intercerebralis. Their average size is 0·063 × 0·028 mm and that of their nuclei 0·018 × 0·01 mm. The nucleus shows a large number of nucleoli besides a few chromatin particles. The cytoplasm is strewn with numerous fine granules distributed evenly throughout.

Of the nucleic acids, RNA is concentrated around the nucleus to form a thick perinuclear ring. The peripheral zone of the cells is entirely free of it. DNA is absent in the nuclei also. The nucleoli are full of RNA.

(B) *Suboesophageal ganglion* Neurosecretory cells situated dorsally in the middle part of the ganglion measure about 0·036 × 0·028 mm. The nuclei are nearly spherical and about 0·012 mm in diameter. Nucleoli are not seen, but chromatin particles occur in abundance. The entire cytoplasm shows evenly distributed granules in the cells of the brain.

(C) *Thoracic ganglia.* The largest cells are situated in the posterior part of each thoracic ganglion and measure about 0·043 × 0·048 mm and their spherical nuclei measure about 0·023 mm in diameter. The cytoplasm contains granules in patches and in association with these occur minute, deeply staining secretory vesicles. The nuclei are nearly devoid of nucleoli and filled heavily with

chromatin granules. RNA is evenly distributed in the cytoplasm. Nuclei are totally devoid of both RNA and DNA.

(D) *Abdominal ganglia.* The largest neurosecretory cells disposed longitudinally in the posterior part of each abdominal ganglion, or on the two sides of its mid-dorsal line, measure about 0·031 × 0·051 mm and their nuclei are about 0·02 × 0·013 mm. The condition of the nuclei and cytoplasm is similar to that of the cells of the thoracic ganglion.

Second stage

(A) *Brain.* Neurosecretory cells in the same position as observed in the earlier stage have attained the size of about 0·064 × 0·035 mm, while the nuclei measure about 0·023 × 0·022 mm. There are no nucleoli, but a large amount of chromatin is visible in small patches. The condition of the cytoplasm and RNA resembles that in the previous stage.

(B) *Suboesophageal ganglion.* The cells under study in this ganglion measure now about 0·04 × 0·028 mm. The nuclei measure about 0 022 × 0·017 mm. Nucleoli are rare but chromatin particles are abundant. The cytoplasmic condition is similar to that of the previous stage.

(C) *Thoracic ganglia.* The cells under observation measure about 0·063 × 0·038 mm. The nuclei measure about 0·022 mm in diameter and the nucleoli are rare but small patches of chromatin granules are present. In the cytoplasm, the vesicles have now increased in size as well as in number. RNA is distributed evenly in the cytoplasm. DNA is completely absent in the nuclei.

(D) *Abdominal ganglia.* Cells of the abdominal ganglia, as studied in the earlier stage, now measure about 0·048 × 0·028 mm with their nuclei measuring about 0·02 × 0·012 mm. Nucleoli are scarce but several patches of chromatin granules are present in the nuclei. As in the thoracic ganglia, the secretory vesicles are larger in size and number. RNA is evenly distributed in the cytoplasm and DNA is throughout absent.

Third stage

(A) *Brain.* Neurosecretory cells under observation in the previous stages now measure about ·0076 × 0·035 mm while their nuclei measure about 0·03 × 0·017 mm. The nuclei contain very few nucleoli but show a large amount of chromatin granules. Unlike the second stage, secretory granules are assembling into small clumps and the development of vesicles starts. The perinuclear ring of RNA has started fading out because the substance is being gradually dispersed towards the periphery.

(B) *Suboesophageal ganglion.* The cells under observation have not undergone any marked change in size but their nuclei have become smaller, about 0·012 mm in diameter. The nuclei are devoid of nucleoli and contain chromatin granules in patches. The condition of cytoplasm is similar to that of the neurosecretory cells of the brain.

(C) *Thoracic ganglia.* The relevant cells are now much smaller, measuring about 0·043 × 0·015 mm and their nuclei measure about 0·023 × 0·015 mm. Nucleoli are scarce but chromatin granules occur abundantly. A number of vesicles have discharged their contents so that the cells contain empty vacuoles as well as secretion filled vesicles. RNA is found evenly distributed throughout the cytoplasm. DNA is completely absent from the nuclei also which are rich in RNA as before.

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(D) *Abdominal ganglia*. The cells or their nuclei have not undergone any significant change in their size since the last stage. Nucleoli are absent and several patches of chromatin particles are seen in the nucleus. The condition of the cytoplasm is similar to that of the cell of the thoracic ganglia.

Fourth stage

(A) *Brain*. Now the neurosecretory cells under observation have increased in size to about 0·079 × 0·051 mm and their spherical nuclei to 0·023 in diameter. In the nuclei, nucleoli are scarce but patches of chromatin substance are abundant. In the cytoplasm the vesicles, which started appearing in the previous stage, have increased in size as well as in number. The process of dispersal of the RNA towards the periphery is nearly complete so that the ring around the nucleus disappears and the substance is evenly distributed throughout the cytoplasm. RNA also fills the nucleoli wherever they are seen.

(B) *Suboesophageal ganglion*. Its cells have now attained maximum size and measure about 0·051 × 0·03 mm while their nuclei measure about 0·018 × 0·013 mm. Nucleoli are rare but chromatin is abundant. The condition of the cytoplasm is similar to that of the neurosecretory cells of the brain.

(C) *Thoracic ganglia*. At this stage, the neurosecretory cells of these ganglia measure about 0·053 × 0·051 mm and their nucleoli have an average diameter of about 0·018 mm. Nucleoli are absent but a large amount of chromatin is present in the nuclei. Vacuoles are abundant and conspicuous. Concentration of RNA starts again and a narrow peripheral region becomes free of it. Nuclei are totally devoid of DNA and the nucleoli are rich in RNA.

(D) *Abdominal ganglia*. The neurosecretory cells in question now measure about 0·046 × 0·03 mm and the nuclei about 0·018 in diameter. As in the neurosecretory cells of the thoracic ganglia, nucleoli are not seen and small patches of chromatin granules are abundant. The condition of cytoplasm is also similar to that of the cells of the thoracic ganglia.

Fifth stage

(A) *Brain*. In this stage, reduction in the size of the neurosecretory cells is observed and now they measure about 0·068×0·045 mm. The nuclei measure about 0·023 mm in diameter. They do not contain nucleoli but abundant chromatin granules. Secretory vesicles, present in the cytoplasm already, become larger. RNA is present evenly almost throughout the cytoplasm. As noted previously the nuclei are devoid of DNA.

(B) *Suboesophageal ganglion*. Neurosecretory cells in this ganglion also show a tendency to become reduced in size and those under observation now measure about 0·035×0·02 mm. Their nuclei measure about 0·018×0·01 mm. Nucleoli are absent and chromatin granules are abundant. As in the neurosecretory cells of the brain, those in this ganglion also show well developed secretory vesicles at this stage.

(C) *Thoracic ganglia*. Cells under observation in these ganglia measure about 0·038×0·051 mm and their nuclei measure about 0·018 mm in diameter. Chromatin granules fill the nuclei and nulceoli are not seen. The cytoplasm is packed with well developed vacuoles. The narrow peripheral region of the cells characterised by the absence of RNA enlarges and consequently the perinuclear concentration of RNA becomes more distinct. Nuclei are totally devoid of DNA.

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(D) *Abdominal ganglia.* The relevant cells of these ganglia measure about 0·04×0·038 mm and their nuclei measure about 0·012×0·02 mm. Nucleoli are absent and chromatin particles occur in small patches in the nuclei. The cytoplasm is full of well developed vacuoles.

Sixth Stage

(A) *Brain.* The cells under observation become smaller still and measure about 0·063×0·03 mm while the nuclei measure about 0·028×0·013 mm. The secretory vesicles start emptying out and become replaced by vacuoles. This indicates the beginning of the discharge of neurosecretory substance from the cells. RNA is present evenly throughout the cytoplasm and also in the nucleoli.

(B) *Suboesophageal ganglion.* Relevant neurosecretory cells at this stage measure about 0·038×0·023 mm and their nuclei measure about 0·02×0·01 mm. Nucleoli are scarce but chromatin granules are abundant in the nuclei. The condition of the cytoplasm resembles that of the cells of the brain.

(C) *Thoracic ganglia.* The neurosecretory cells in these ganglia now increase in size to about 0·045×0·051 mm and their nuclei measure 0·028×0·023 mm. The cytoplasm shows evenly distributed granules. RNA becomes richly concentrated in the perinuclear region and the rest of the cytoplasm becomes free from it. DNA is absent from the nuclei which contain an abundance of chromatin but no nucleoli.

(D) *Abdominal ganglia.* The neurosecretory cells under observation measure about 0·038×0·033 mm and the nuclei about 0·015 in diameter. The cytoplasm is filled with evenly distributed secretory granules and the nuclei with chromatin.

Seventh stage

(A) *Brain.* The cerebral neurosecretory cells under observation and their nuclei have not undergone any significant change in size and measure about 0·06×0·035 mm and 0·025×0·015 respectively. The entire cell cytoplasm is packed with large vacuoles. RNA is showing a tendency to become concentrated in the perinuclear region and a thin peripheral region becomes free of it. The nuclei have only a few nucleoli but plenty of chromatin granules.

(B) *Suboesophageal ganglion.* Neurosecretory cells of this ganglion now measure about 0·035×0·02 mm and the nuclei measure about 0·01×0·013. As in the case of the cerebral neurosecretory cells, nucleoli are scarce and chromatin granules are abundant. The cytoplasm is full of conspicuous vacuoles.

(C) *Thoracic ganglia.* Its cells measure 0·04×0·048 mm and their nuclei about 0·018 mm in diameter. The cytoplasm is strewn with evenly distribuied secretory granules but at places, they form masses and give rise to small vesicles. The perinuclear concentration of RNA becomes less conspicuous and the substance has started spreading out in the cytoplasm. The nuclei are devoid of DNA and the nucleoli, if present, are full of RNA.

(D) *Abdominal ganglia.* The neurosecretory cells under observation in these ganglia now measure about 0·04×0·035 mm and the nuclei measure about 0·01×0·018 mm. The conditions of the cytoplasm and nuclei resemble those of the cells of the thoracic ganglia.

PLATE 1. Camera lucida drawings of the neurosecretory cells of the brain and suboesopha-geal ganglion of *Periplaneta americana* showing secretory activity in these.

a, A neurosecretory cell of the pars intercerebralis of the brain in the 1st stage, showing even-ly distributed granules in the cytoplasm.

b, Same in the 2nd stage with the cell enlarged and full of granules.

c, Same in the 3rd stage, showing aggregation of granules and beginning of vesicles formation.

d, Same in the 4th stage with vesicles larger and more abundant and with fewer granules.

e, Same in the 5th stage, showing well developed vesicles filling the entire cytoplasm.

f, Same in the 6th stage, showing the beginning of discharge of vesicles and formation of vacuoles.

g, Same in the 7th stage, showing numerous large vacuoles but no vesicles.

al, A neurosecretory cell of the suboesophageal ganglion in the 1st stage, showing evenly dis-tributed granules throughout the cytoplasm.

bl, Same in the 2nd stage with the cell size larger.

cl, Same in the 3rd stage, showing aggregation of granules and the beginning of the forma-tion of vesicles.

dl, Same in the 4th stage, showing that the vesicles have enlarged and the granules are much reduced

el, Same in the 5th stage, showing well developed secretory vesicles filling the entire cell.

fl, Same in the 6th stage, showing discharging vesicles and beginning of appearance of vacuoles.

gl, Same in the 7th stage, showing numerous large vacuoles in the cytoplasm and the vesicles absent.

PLATE 2. Camera lucida drawings of the neurosecretory cells of the thoracic and abdominal ganglia of *Periplaneta americana* showing secretory activity in the different stage (1st to 7th) as given in the 'Observations'.

a, A cell of the thoracic ganglion in the 1st stage, showing developing vesicles and granules in the cytoplasm.

b, Same in the 2nd stage, showing cytoplasm full of well developed vesicles

c, Same in the 3rd stage, showing secretory versicles some of which are discharging and giving rise to vacuoles.

d, Same in the 4th stage, showing an increasing number of vacuoles.

e, Same in the 5th stage with the cytoplasm full of vacuoles

f, Same in the 6th stage with the cytoplasm full of evenly distributed granules.

g, Same in the 7th stage, showing the aggregation of granules and the appearance of vacuoles.

al, A neurosecretory cell of an abdominal ganglion in the 1st stage, showing developing vesi-cles and granules in the cytoplasm.

bl, Same in the 2nd stage, showing the whole cytoplasm full of secretory vesicles.

cl, Same in the 3rd stage both vesicles and vacuoles.

dl, Same in the 4th stage showing a larger number of vacuoles and some vesicles.

el, Same in the 5th stage with the whole cytoplasm full of vacuoles.

fl, Same in the 6th stage, showing evenly distributed granules in the cytoplasm.

gl, Same in the 7th stage showing beginning of the appearance of vesicles.

PLATE 3. Photomicrograph of neurosecretory cells of the brain and thoracic ganglion showing RNA (Methyl green-pyronin staining). (Cell marked by an arrow).

a, A neurosecretory cell from the brain, showing a perinuclear concentration of RNA.

al, A neurosecretory cell from a thoracic ganglion in the same stage as above, showing evenly rich distribution of RNA through out the cell.

b, A neurosecretory cell of the brain, showing even distribution of RNA in the cytoplasm.

bl, neurosecretory cell of a thoracic ganglion in the same stage as above (b), showing a rich perinuclear concentration of RNA.

ABBREVIATIONS USED

C, Chromatin ; G, Granules ; N, Nucleus ; Nu, Nucleolus ; V, Vesicles: VA, Vacuoles.

PLATE 1
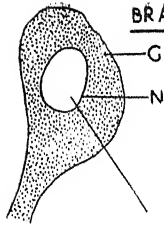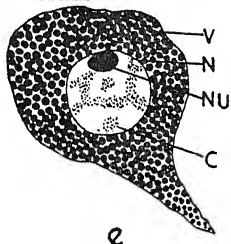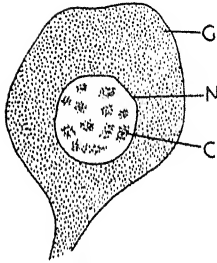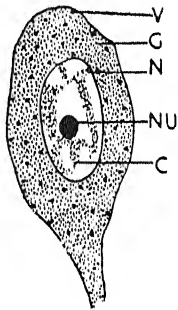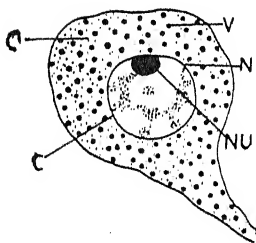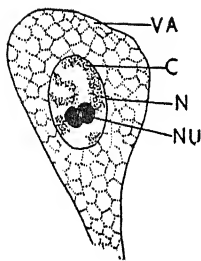
BRAIN CELLS   SUB OESOPHAGEAL GANGLION CELLS
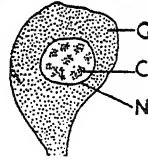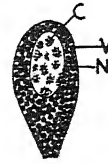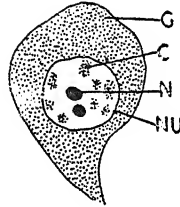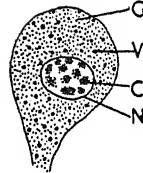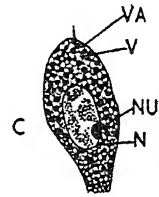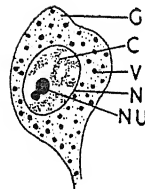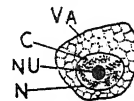
PLATE 2

THORACIC GANGLIA CELLS   ABDOMINAL GANGLIA CELLS

PLATE 3

a

al
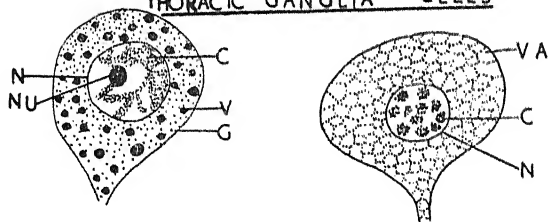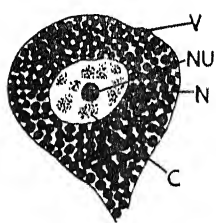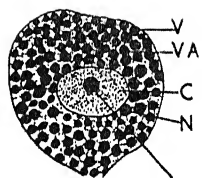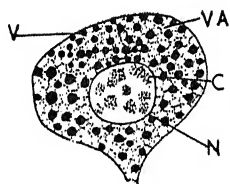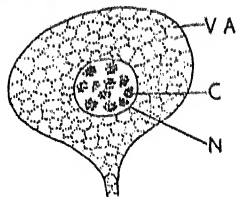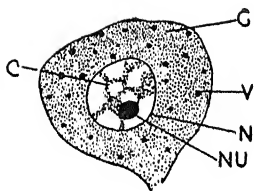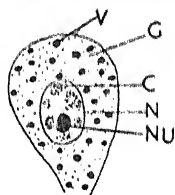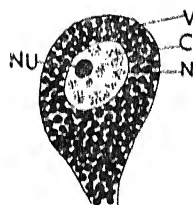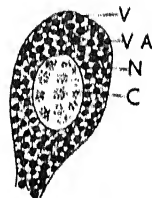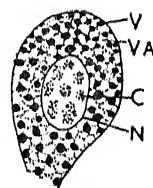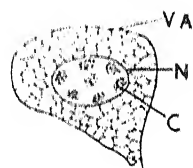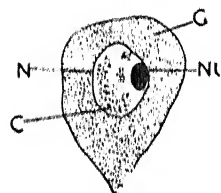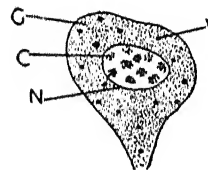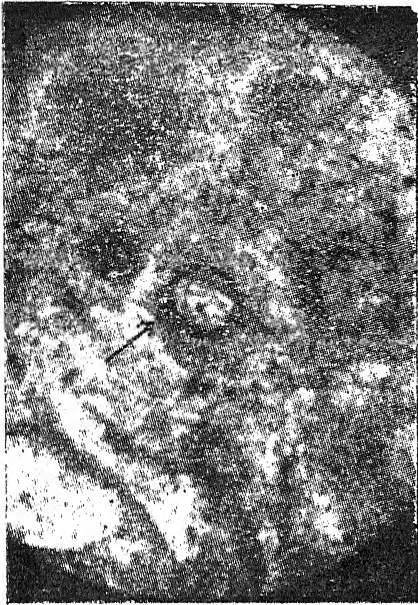
b

bl

Discussion

Kaiser (1954), Luscher and Engelmann (1955) and others have shown by histological methods that the corpora allata control egg production and undergo a secretory cycle which is correlated with the ovarian cycle. It has been established that the corpora allata themselves are stimulated to secretory activity by the neurosecretory cells which send their secretory product either through the allatic nerve and corpora cardiaca or through blood (Wigglesworth, 1948 ; Joly, 1950 ; Scharrer, 1946 ; Thomsen, 1952, etc.). It is also usually beleived that these neurosecretory cells belong to the pars intercerebralis of the brain. However, Thomsen (1948) noted that, in certain cases, even though the median neurosecretory cells of the brain were removed, the ovary showed some development In this connection, she also recalled the observation of Williams (1947) that in breaking the diapause of *Platysamia cecropia*, not only the median but also the lateral neurosecretory cells take part. Besides, Scharrer (1955) pointed out the possible relationship between the ovary and the suboesophageal ganglion on the basis of the observation of 'castration cells' in the latter. All these observations thus tend to show that the ovarian activity is influenced by neurosecretory cells which may not only belong to the region of the pars intercerebralis of the brain, but to its other parts, as well as to other ganglia.

In the present work it has been established that secretory activity takes place in the brain and in the oesophageal, thoracic and abdominal ganglia of cockroach and their secretory cycles correspond with the ovarian cycle. Thus apparently the ovarian activity is related to the secretory activity in all these ganglia. It is, nevertheless, intriguing to note that there appear to be two distinct secretory cycles. At any time, neurosecretory cells of the brain and the suboesophageal ganglion are in one phase, while the cells of the thoracic and abdominal ganglia are in another phase. This raises the question whether these two cycles, and the cells which demonstrate these, are concerned with two different functions. It is difficult to answer this question. Thomsen (1952) had noted that the removal of the median neurosecretory cells in *Calliphora* led to the arrest of development of the ovaries at a stage earlier to the one at which yolk formation begins. She also observed that the removal of the corpora allata or cerebral neurosecretory cells leads to deposition of less fat in fat bodies. Conversely, Gersch (1959) showed that the removal of ovaries caused excessive fat deposition in fat bodies. These observations indicate that the median neurosecretory cells may be connected with the production of fat and possibly also yolk. Since neurosecretory cells all over the brain and in the suboesophageal ganglion run the same secretory cycle, we may infer that all these cells are concerned with this function. Cells of the thoracic and abdominal ganglia, which pour their secretion earlier than cells of the brain, may be connected with the process of growth of ova in size and hence with a different metabolic process. It is also worth investigating whether the secretion of the first set is passed out through the allatic nerve into the corpora allata and that of the second set directly in the blood.

The study of nucleic acids reveals an abundance of RNA in the cytoplasm and the nucleoli, when the latter are present, and a relationship between the activity of RNA and the secretory state of the cell. When there is an intense perinuclear concentration of RNA, the cytoplasm shows evenly distributed secretory granules. As RNA spreads out, secretory granules cluster and vesicles arise. The presence of RNA in the neurosecretory cells has been reported earlier by Nayar (1956). The present work establishes its relationship with the secretory

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activity of the cells. It has been shown earlier that RNA occurs wherever protein molecules are being formed in the cell and its presence has been considered necessary for protein synthesis (Swift, 1953) ; hence its abundance in the neuro-secretory cells may be considered indicative of the chemical nature of the secretory material.

Summary

The neurosecretory cells of the brain and the suboesophageal, thoracic and abdominal ganglia of the female *Periplaneta americana* show secretory activity which is correlated with the ovarian cycle, but while the cells of the brain and the suboesophageal ganglion are in one cycle and discharge their secretory product when the last ova have reached near maximum development, those of the thoracic and abdominal ganglia are in another cycle and discharge their product much earlier, when the ova are middle sized. The neurosecretory cells are rich in RNA the activity of which is also correlated to the secretory activity of the cells. DNA is absent. Different secretory cycles in the cells of the two sets of ganglia may be responsible for different functions, and abundance of RNA may be indicative of the proteid nature of the secretion.

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'ALIENS' NATURALISED IN THE FLORA OF ALLAHABAD

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According to Hooker (1904), Champion and Trevor (1938) the flora of India is merely a mixture of floras of the surrounding countries and that there is no Indian flora as a separate entity. Chatterjee (1940, 1962) does not share this view and maintains that more than 60% of our Dicotyledonous species are endemic and considers that there was originally a typical Indian flora which became partly masked by plant invasions from the surrounding countries. He hewever, considered that the Indo-Gangetic Plain is relatively poor in the endemic species. He criticised the recognition of floristic regions by Good (1947) according to whom India is a region of the Indo–Malayan Subkingdom under Paleotropical Kingdom. Chatterjee, therefore, divided India into 8 phyto-geogra-phical regions of which "Gangetic Plains" is one.

J. K. Maheshwari (1962) from his studies in the flora of Delhi and Srivastava (1964), amongst others, have drawn attention to the 'studies on the naturalised flora of India'. According to Maheshwari (*l. c.*) about 40% of the flowering plants of India are foreign and are now naturalised in different parts of the country. Maheshwari (*l. c.*) recognised four distinct categories amongst the naturalised elements *viz.* (1) Pluri-regional species or 'wides', (2) Weeds of cultivation and other introduced weeds, (3) Exotics and escapes from cultivation, and (4) Species of limited distribution in India and adjoining regions. van Steenis (1964) is, however, highly critical of Maheshwari's (1962) list of naturalised species, considers that many native plants have been treated as introduced ones, and since there is no mention of the time at which naturalisation took place, he expresses his mis-givings on the aim of the paper itself.

Our own studies under the project of 'Illustrated Mannual of Flora of Allahabad' have yielded about 580 species, of which about 299 species represent indigenous elements, 70 species introduced and naturalised elements from outside India and the remaining cultivated crops or ornamental species of horticultural interest.

The introduced and naturalised species collected and identified uptodate represent about 20% of the 'wild flora' of the city of Allahabad. This would contrast with the report of about 27% of introduced and naturalised species out of total 478 indigenous and naturalised species for the Delhi city (*c.f.* Maheshwari 1962, 1963). Whether the percentage of introduced species in the flora of the Allahabad city would go up higher after further collection and identification remains to be seen.

The analysis of the 70 species recognised here as 'introduced and naturalised' elements from countries beyond India are presented under the heading I. Neo-tropical—36 sepcies, II. North-temperate—20 species, III. North African

and Arabian—4 species, IV. Tropical and South African—7 species, V. Austro-asian—2 species, VI. Burmese—1 species.

In view of the criticism of Maheshwari's (1962) list of species by van Steenis (1964) and considering the unsatisfactory nature of the connotations *viz.* Cosmopolitan, Paleotropical and Pantropical etc. in determining the 'exotic' and 'indigenous' nature, the question of determining the nativity of our other species is under study.

An enumeration of the species with notes on the habitat and the source of its introduction etc. are appended herewith.

I. NEO-TROPICAL (*i.e.* Mexico, West-Indies and Trop. S. America).

Alternanthera paronychioides St. Hill.

Grows gregariously on the alluvial loamy banks of the river Ganges but in the drier situations near MacPharson Lake ; the plants are rather stunted with condensed internodes.

A native of S. America and West-Indies, it was not recorded in Indian Floras ; probably introduced during first quarter of this century. Raizada (1939), records this species from Banaras and Kanpur ; Sunderaraj (1955) records it from South India.

A. pungens H. B. et K.

In dry situations, waste places and along roadsides.

A native of Tropical America (Backer and Brink 1963 ; Raizada 1950). According to Raizada (*l.c.*) it was introduced into this country about 1913, since it was first collected on the Malagiri hills in Salem district, Madras in 1913. The species has rapidly spread throughut the country and has been reported from Coimbatore, Bangalore, Bombay, Hyderabad, Keonjhar, (Orissa), Delhi and Meerut etc. Its rapid spread can be attributed to the stiff perianth enclosing the utricle, which readily attaches itself to clothes, to passing animals and to the tyres of the vehicles.

Ageratum conyzoides Linn.

In shady situations, as a common weed in gardens and near water channels of fields.

A native of S. America, probably introduced to India in the 16th century. It travels by adhesion to clothes or to hair of animals and is a weed of cultivation (Ridley, 1930). Baker (1964) attributes its enormous success as a weedy annual to (*a*) its ephemeral nature *viz.* from seed to flowering it takes less than two months, (*b*) plasticity in growth habit *i.e.* can grow successfully from water-logged to drier habitats and produce 1 to 100 capitula per plant, (*c*) self-compatibility and self-fertilising mechanism which ensures good seed production.

Argemone mexicana Linn.

In waste places, dry open grounds, on river banks and as a winter weed in fields and gardens.

A native of Central America and West-Indies (Ridley 1930, Backer and Brink 1963), probably introduced during the 17th century and now found throughout India.

A. ochroleuca Sweet.

Along with *A. mexicana* Linn. on the banks of the Ganges and on Mela grounds near Sangam (*see* Rajagopal, 1965).

A native of Mexico, most probably introduced at the time when Duthie was writing his Flora, because under *A. mexicana* Linn., he describes the "flowers rarely white". The white-flowered biotypes seen by Duthie could be those of *A. ochroleuca* Sweet.

Blainvillea acmella (Linn.) Philipson *B. rhomboidea* Cass. and *B. latifolia* (Linn.) DC.

In shady situations and moist places. A native of S. America (Ridley, 1930) and was probably introduced during the 18th century. It spreads due to its achenes adhearing to sacks and baggages.

Cassia occidentalis Linn.

Common in waste places, along roadsides and as a weed in culivated land.

Native of S. America (Duthie 1903, Backer and Brink 1963), probably introduced long back before Roxburgh's *Flora Indica* was written.

Cissampelos pariera Linn.

On hedges and bushes.

A native of S. America. According to Ridley (1930), it was brought by Jesuit Missonaries in the 17th century to Goa since it was considered the source of the true 'Tariara brava', obtained from *Clerodendrum tomentosum*. It spreads by red drupes eaten by birds.

Coldenia procumbens Linn.

In moist places and river banks.

Coldenia is exclusively a new world genus (Good 1947). This is the only species of the genus in India and was probably introduced before Roxburgh's *Flora Indica*.

Corchorus aestuans Linn. (non Forsk).

In waste places, in gardens and on field bunds.

Although Maheshwari (1962) treats this species as a native of tropical America, Brizicky (1965) considers *C. aestuans*, a diploid species with $2n = 14$, as either Asiatic or African in origin but as an adventive weed in America (Florida).

Coronopus didymus (Linn.) Sm. *Senebiera pinnatifida* DC.

Common weed during winter in gardens and fields.

Duthie (1903) considers the species as tropical American in origin; it was introduced into Bengal during 1845 (Srivastava 1964).

Croton bonplandianum Baill *C. sparsiflorus* Mor.

Very common in waste places, along road sides and railway tracks and in gardens.

According to Ridley (1930), it is a native of tropical America, introduced into Chittagong along with ballast about 1897 and reached Calcutta by 1920. It is now spread more or less throughout India by 'trecking', as if, along the railway lines.

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Eclipta prostrata Linn. *E. alba* Linn.

In moist places, near ponds and drainage channels, as a weed in lawns. This shows great plasticity in its growth habit, from prostrate herb in lawns to erect plants with succulent stems near water edge.

Ridley (1930) who considers it as a native of S. American swamps, suspects that it spreads by attaching to plumage of birds and also by human beings since the achenes are viscid.

Eichhornia crassipes (Mert.) Solms.

In ponds, ditches and in flooded part of the river banks during the rains.

Native of Brazil, introduced into the Old World by about 1829 on account of its beautiful flowers (Ridley 1930). In India, it rarely sets seeds and depends generally on vegetative propagation.

Euphorbia heterophylla Linn. *E geniculata* Orteg. (*c.f.* Dressler 1961 Ann. Moss. Bot. Gard. 48 : 329–341).

In waste places, fallow lands and as a weed in gardens.

A native of tropical America ; introduced in gardens before Hooker wrote the *Flora of British India.*

E. hirta Linn.

Very common throughout Allahabad in fallow lands, in lawns, waste places and along road sides.

Backer and Brink (1963) consider it as a native of Tropical America ; probably introduced before Roxburgh wrote his '*Flora Indica*'.

E. thymifolia Linn.

Abundant in the cleared places, in lawns, waste places and along road sides.

Probably tropical American in origin (Backer and Brink, 1963) and might have been introduced at a very early time.

Galinsoga parviflora Cav.

Near the hedges of the Central Circle garden ; scarce.

Indigenous to South America (Duthie, 1903) ; introduced to India before 1845 (Ridley, 1930).

Gnaphalium purpureum Linn.

Common in moist shady places and in gardens during winter.

Native of Tropical America (Duthie, 1903) ; time of introduction not known.

Gomphrena celosioides Mart.

In waste places, on river banks, bunds of fields and along road sides.

A native Tropical America, introduced in South Africa, India, Australia and Malayasia (Backer, 1954). First reported in India from Madras and Coimbatore by Gamble (1915) ; Raizada (1950) records it from the upper Gangetic Plain. van Steenis (1965) states "In Timor I got the tentative impression that the rapid 'long-distant' dispersal of this alien is due to transport by aeroplanes, as it was especially abundant on the airstrips or confined to them. It could have been

brought along with luggage but it seems more likely that seeds are adhearing with mud to tyres".

Heliotropium indicum Linn.

On moist grounds, along river banks and road sides.

South American in origin, introduced at about 1500 AD in India, probably in ballast or baggage (Srivastava 1964).

Jatropha curcas Linn.

In waste grounds and in abandoned places ; also planted as a hedge.

A native of Tropical America (Duthie, 1903, Backer and Brink, 1963), probably introduced at an early time.

J. heterophylla Steud. *J. gossypifolia* Linn.

In waste places.

A native of Tropical America (Backer and Brink, 1963) introduced in India probably after 1850 and had become quite common in Bihar by 1921–25 (Srivastava, 1964).

Lantana camara Linn. var. **aculeata** (Linn.) Moldenke (Planters' curse).

In waste places, as an escape in gardens and generally grown as a hedge.

South American, introduced for its ornamental flowers to Ceylon in 1824 (Srivastava, 1964) and spreads by birds and squirrels who relish its black berries (Ridley, 1930).

Malvastrum coromandelianum Gareke. *M. tricuspidatum* A. Gray.

On the slopes of the MacPharson lake bunds and in shady situations.

Native of South America (Backer and Brink, 1963), introduced into India during 1900 (Srivastava, 1964).

Martynia annua Linn.

In waste places and road sides.

Native of Mexico and Brazil and introduced to India before 1843 ; spreads by attachment of its hooked fruits to wild beasts, goats, sheep (Ridley, 1930).

Nicotiana plumbaginifolia Viv.

In hedges and bushes ; in shady situatiens along road-sides and on river banks.

Mexican in origin, introduced into India probably during 1824–45 (Srivastava, 1964).

Oxalis intermedia A. Rich. *O. latifolia* auct. non H. B. et K.

In moist situations in gardens and along hedges.

Native of Tropical America (Backer and Brink, 1963), probably introduced during last part of the 1800 AD and propagates vegetatively by its bulbs, never seen setting seeds.

O. martiana Zucc. *O. corymbasa* DC.

In moist situations of gardens.

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A native of South America (Ridley, 1930), spreads by underground bulbs and it rarely fruits outside its native house. According to Moon (c.f. Ridley l.c.), it was well established in the forests of India by 1817.

Passiflora foetida Linn.

On hedges and bushes.

Native of Brazil (Duthie, 1903) and America (Ridley, 1930), introduced into India before 1845 (Srivastava, 1964).

Physalis minima Linn.

In moist places, hedges and fallow lands.

A native of South America, spreads through the dung of cattle, horses etc., probably introduced during the 17th century to India from Malaya Peninsula (Ridley, 1930).

Ruellia tuberosa Linn.

In shady situations, hedges, along road sides and in gardens.

A native of Tropical America, introduced for its ornamental flowers, naturalised in Bengal by 1903 (Prain, 1903).

Scoparia dulcis Linn.

On river banks, along road sides and as weed in gardens.

Ridley (1930) states that Linneaus described it from Jamaica in 1753 ; came to Africa in ships connected with the slave trade. In India, introduced as a medicinal plant by Chinese Physician (?) round about 1843 (Srivastava, 1964).

Sorghum halepense Pers.

In hedges, on field bunds, and in orchards and gardens.

Snowden considers it as a native of Tropical America (c.f. Bor, 1960), probably introduced to India at a very early time.

Tridax procumbens Linn.

In hedges, fallow lands, along road sides and on old walls.

Introduced to India as an ornamental plant before 1830 from South America (Ridley, 1930). It is very wide-spread now.

Volvulopsis numularia (Linn.) G. Roberty *Evolvulus nummularius* Linn.

Abundant in waste places, fallow lands, along road sides, river banks and on field bunds.

Native of Tropical America (Roberty, 1952), probably introduced in India during last part of the 18th century, since it is recorded in the Flora of British India 4, p. 734 under additions and corrections. Tiwary (1930) reports it from Banaras and Raizada (1936) from Dehra Dun.

II. NORTH-TEMPERATE (*i.e.* Eurasian, Mediterranean, including Central Asia and China)

Anagallis arvensis Linn.

Common winter weed along road side drains and in moist situations.

Taylor (1955) while rivising the genus *Anagallis* for Tropical and South Africa, considers *A. arvensis* indigenous to Europe and Mediterranean region and "as an introduced weed" in Africa ; probably introduced to India at an early time.

Cannabis sativa Linn.

Weed in moist situations and in gardens.

A native of Central Asia, cultivated either as a fibre plant or as a narcotic in many other countries (Backer, 1954) ; probably introduced to India at an early time.

Convolvulus arvensis Linn.

A weed in cultivated lands during winter.

Indigenous to Old World Temperate region, now spread to the sub-tropical and tropical regions.

Cyamopsis tetragonoloba (Linn.) Taub.

Commonly occurs in fallow lands and waste places as an escape from cultivation.

A native of Central Asia (Backer and Brink, 1963), introduced to India probably at a very early time.

Eruca sativa Mill.

A winter weed in wheat and *Brassica* fields.

Indigenous to South Europe, North Africa and West Asia (Duthie, 1903) and probably introduced during the 17th century.

Fumaria indica (Housk.) Pugsley *F. parviflora* Wt. et Arn.

A common winter weed.

Its occurrence in North India during winter and in South India at high altitudes as a weed in cultivated lands, indicates its temperate origin ; probably introduced at a very early time and according to Mason, the Indian jungle-crow eats fruits of this species and helps in its dissemination (*see* Ridley, 1930).

Lathyrus aphaca Linn.

Common winter weed in fields.

Indigenous to Europe ; according to Ridley (1930) it might have been introduced to India along with vegetable seeds from Europe during the 16th century.

Medicago polymorpha Linn. *M. denticulata* Willd.

In moist places and as a common winter weed in cultivated lands.

Native of Europe and probably introduced during the 15th or the 16th century alongwith wool to which it adheres by its curved spinous fruits (Ridley 1930).

M. lupulina Linn.

In moist places, in gardens and cultivated lands during winter.

Native of Europe (Ridley, 1930), probably introduced by European settlers along with vegetable seeds during the 15th or the 16th century.

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Melilotus alba Desr.

In hedges, in fallow lands and gardens.

Indigenous to Europe and Western Temperate Asia. Ridley (1930) refers to its seed dispersal through horse dung in Sweden ; may probably be an early introduction to India.

M. indicus (Linn.) All.

Generally associated with *M. alba* Desr.

Native of South Europe and South Western Asia (Backer an d Brink 1963) : probably an early introduction.

Oxalis corniculata Linn.

Common in moist places, gardens, field bunds and near drainage channel.

Ridley (1930) states, "this creeping plant is very widely spread all over the world, mainly by human agency. It is certainly a native of South Europe and was described by Cluspius as coming from the region in 1549. It is also probably native in the north temperate zone of the Old World, being specially common in India, where there is a hairy form and which also occurs in other warm part of the Old World."

Polypogon monspeliensis (Linn.) Desf.

On a sandy alluvial soils and on field bunds and in gardens.

Indigenous to temperate parts of Asia, Africa and Europe and introduced in India (Bor, 1960) ; time of introduction not known.

Sonchus oleraceus Linn.

A common weed in gardens, in shady situations and near drains.

Probably indigenens to Europe and Eurasian region (Duthie, 1903) and it is now more or less cosmopolitan in its range.

Spergula arvensis Linn.

Common in moist situations, in field and gardens during winter.

European in origin (Ridley, 1930, Backer and Brink, 1963) ; probably introduced along with European vegetable seeds during the 17th century. Ridley (1930) says in this connection ". . . . many plants however they arrived in distant countries originally, are now widely disseminated by cattle more extensively. Some of these weeds are so extensively distributed and so much confined to cultivated land that it is dubious as to what part of the world they originated in".

Vaccaria pyramidata Medick. *Saponaria vaccaria* Linn.

A weed in wheat fields.

Native of Europe (Backer and Brink, 1963) ; probably introduced during the 16th century. Kalmbach (*c.f.* Ridley, 1930) reports the dispersal of the seeds of this species by the American crow which feeds on the dry fruits and also visits distant countries.

Veronica anagallis-aquatica Linn.

In marshy places, on edges of water channel and on the river banks.

A native of Temperate region (Maheshwari, 1962) ; time of introduction uncertain.

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Vicia hirsuta Gray.

In moist shady places, in gardens and fields as winter weed.

Backer and Brink (1963) consider it as a native of Europe, West Africa and continental Asia, and Duthie (1903) states, "most likely originally introduced from Europe where the plant is common".

V. sativa Linn.

A common weed of cultivation and in moist situations.

"Wild throught greater part of Europe and was no doubt introduced into India from that direction", Duthie (1903). Backer and Brink (1963) consider it as a native of Europe, North Africa and West Asia; probably both the species of *Vicia* were introduced during the 16th or 17th century by the European invaders.

Xanthium strumarium Linn.

Weed in vaste places, in drying ponds, on bunds of fields and in gardens.

Ridley (1930) considers it as a native of Europe on the authority of Dioscorides who figures this plant from Europe in the 1st century. It spreads by its spiny adhearing fruits. But Srivastava (1964) attributes it to South American nativity and states "introduced into India long back, as it is found even in the interior of the Himalayas and is mentioned in Ayurvedic texts".

III. NORTH AFRICAN AND ARABIAN

Acacia nilotica Del. *A. arabia* Linn.

In dry situations, open grounds and on banks of river Yamuna.

A native of North African Arabian desert and probably introduced at a very early time by the Muslim invaders, after the 11th century.

Aristida adscencionis Linn.

In open grounds, field bunds and in gardens during the rains and in early part of winter.

According to Ridley (1930), "it is a native of North Africa but is described as a Madras plant by Plunket in 1696"; evidently introduced to India prior to this date.

Digera muricata (Linn.) Mart.

On river banks and in gardens and fields as a weed; probably native of North Africa; time of introduction not known.

Portulaca oleracea Linn. 'Purslane'—English.

In moist situations, on river banks and in gardens.

A native of North Africa, probably introduced along with vegatable seeds carried by early explorers in the 15th century (Ridley, 1930).

IV. TROPICAL AND SOUTH AFRICAN

Chloris barbata Sw.

Open grounds, in hedges and in gardens as a weed.

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Ridley (1930) who himself considers it as a native of Tropical Africa, states that according to Rheede (1769), it is a native of India ; it spreads by attaching its awns to packing materials.

Corchorus olitorius Linn.

In moist situations, near rain water ponds and in gardens.

According to Brizicky (1965), it is African and cultivated as a pot herb in the Eastern Mediterranean, particularly in Egypt, from ancient time ; probably introduced at an early time in India.

Merremia emarginata (Burm.f.) Hall.f.

In wet places and in orchards near Baxiband road.

Indigenous to Tropical Africa and according to Merrill (1918 ; Sp. Blanc., 324), the species has all the appearance of being an introduced one in the Philippines, as it occurs only in the settled areas (*c f.* Flora Malaesia Ser. I. Vol. 4) ; date of introduction to India not known.

Oxalis pes-caprae Linn.

In moist places in gardens, during winter.

A native of Cape of Good-Hope (Fyson, 1915) ; Raizada (1950) first recorded it from the Upper Gangetic Plain.

Plumbago zeylanica Linn.

Generally cultivated, sometimes a garden escape.

African in origin (Ridley, 1930) ; time of introduction not known.

Sesbania sesban Merr.

In open grounds and also cultivated.

Duthie (1903) considers it as indigenous to South Africa. According to Ridley (1930) it spreads by seeds mixed on rice grains. Time of introduction not known.

Urena lobata Linn.

In hedges, and waste places and in gardens.

Probably an inhabitant of Africa (Ridley, 1930) ; spreads by its spinous, adhearing fruits ; introduced before Roxburgh wrote his *Flora indica*.

V. AUSTRO-ASIAN

Indigofera linnaei Ali *I. enneaphylla* Linn.

In open grounds along with grasses and as a weed in fields and gardens.

A native of Tropical Australia and Asia (Maheshwari, 1962).

I. trita Linn.

In open grounds and as a weed in gardens.

Indigenous to Tropical Australia and Asia (Maheshwari, 1962).

VI. BURMESE :

Azadirachta indica Juss.

In open grounds, as epiphyte on *Ficus* and also planted along road sides and in gardens.

Benthal (1946) considers it a native of Burma. It is recorded in ancient ayurvedic literature.

The herbarium sheets representing field collection of plants from Allahabad city areas and representing the species discussed here are deposited in the Regional Herbarium of the Central Circle, Botanical Survey of India, Allahabad.

Summary

Chatterjee (1962) and J. K. Maheshwari (1962) amongst others, have drawn our attention to the studies on the "endemic flora" and on the "introdueed and naturalished flora" of India, respectively. van Steenis (1964) is, however, highly critical of Maheshwari's (*l.c.*) list of naturalised species, considers that many native plants have been treated as "introduced" and since Maheshwari does not mention the time at which naturalization took place, van Steenis expresses his misgivings on the aim of the paper itself.

Our own studies under the project "Illustrated Manual of Flora of Allahabad" have yielded 299 "indigenous species" and 70 introduced and naturalized elements from outside india. The paper presents an analysis of these 70 naturalized species under six categories *viz.* (*i*) Neo-tropical—36 species ; (*ii*) North-temperte—20 species ; (*iii*) North African and Arabian—4 species, (*iv*) tropical and South African—7 species ; (*v*) Austro-Asian—2 species ; (*vi*) Burmese—1 species.

An enumeration of the 70 species under the above six categories together with notes on the habitat the species occupies, its source of origin and the time of introduction to India, as far as determinable, is appended to the paper.

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A GLACIOLOGICAL STUDY OF THE GARHWAL-KUMAUN HIMALAYA

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Location of the region :

The Garhwal-Kumaun, Himalayan Region, exists between 29°0′–31°30′ N. latitudes, and 77°40′–81°0′ E. longitudes. The area lies between Himachal Pradesh and Nepal ; and it comprises the source regions and upper-most systems of all the affluents forming the rivers Ganga, Yamuna and Sarda.

Essentiality of the study of Himalayan Glaciology :

A study of the glaciology of the Himalayas is desirable for two reasons :

(1) The Himalayas provide a very typical study in mountain glacierisation, with numerous and varied features and characteristics. Such a typical study is not present in any other region on the earth : neither in the Alps, nor Rockies nor Andes. And the sheet glacierisation of Greenland and Antarctica is quite different from mountain glacierisation.

(2) The rivers of the northern plains of India, which support the major part of the population of the country, have their perennial sources in the glacial areas of the Himalaya. The continuity of water-supply and its periodic fluctuations, for irrigation and hydel-power, are controlled not only by rainfall but also the snowfall and glacial thaw.

Glacier groups of the region :

A vast area of glaciers and glaciated topography exists in the Garhwal-Kumaun Himalaya, in which the Main Himalaya Range has a good number of high peaks—Nanda Devi, Kamet, Mana, Chowkhamba, Trisul, Badrinath, Satopanth, Dunagiri, Niti, etc. are all above 7,000 meters (23,000 ft.). Between the Tons and Kali Ganga, there are about 80 peaks above 6,000 meters (20,000 ft.); and the area all around these peaks consists of mountain glaciers and glacial topography. The glaciers of this region are divisible into 8 groups :

(1) Yamunotri group.
(2) Gangotri-Satopanth group.
(3) Kamet group.
(4) Dhauli Ganga Zone.
(5) Nanda Devi group.
(6) Pindari group.
(6) Milam group.
(8) Panchu group.

(1) The Yamunotri group consists of the Yamunotri glacier, Jakhli Bamak and Chhaian Bamak. It forms the source region of the Yamuna and Tons, a tributary of the former.

(2) The Gangotri-Satopanth group is the largest one. It spreads over an area of more than 4,000 sq. km. (about 80 km. length and 51 km. in breadth). Bhagirathi, Jad Ganga (Jahnavi), Bhillangana, Mandakini, and Alaknanda have their sources in this group. It consists of Dudu Bamak, Jaonli Bamak, Khatling Bamak, Phating Bamak, Kedarnath glacier, Kharcha Khund, Badrinath glacier, Chowkhamba, Bhagat Kharak glacier, Mana glacier, Bidun and Satopanth glaciers.
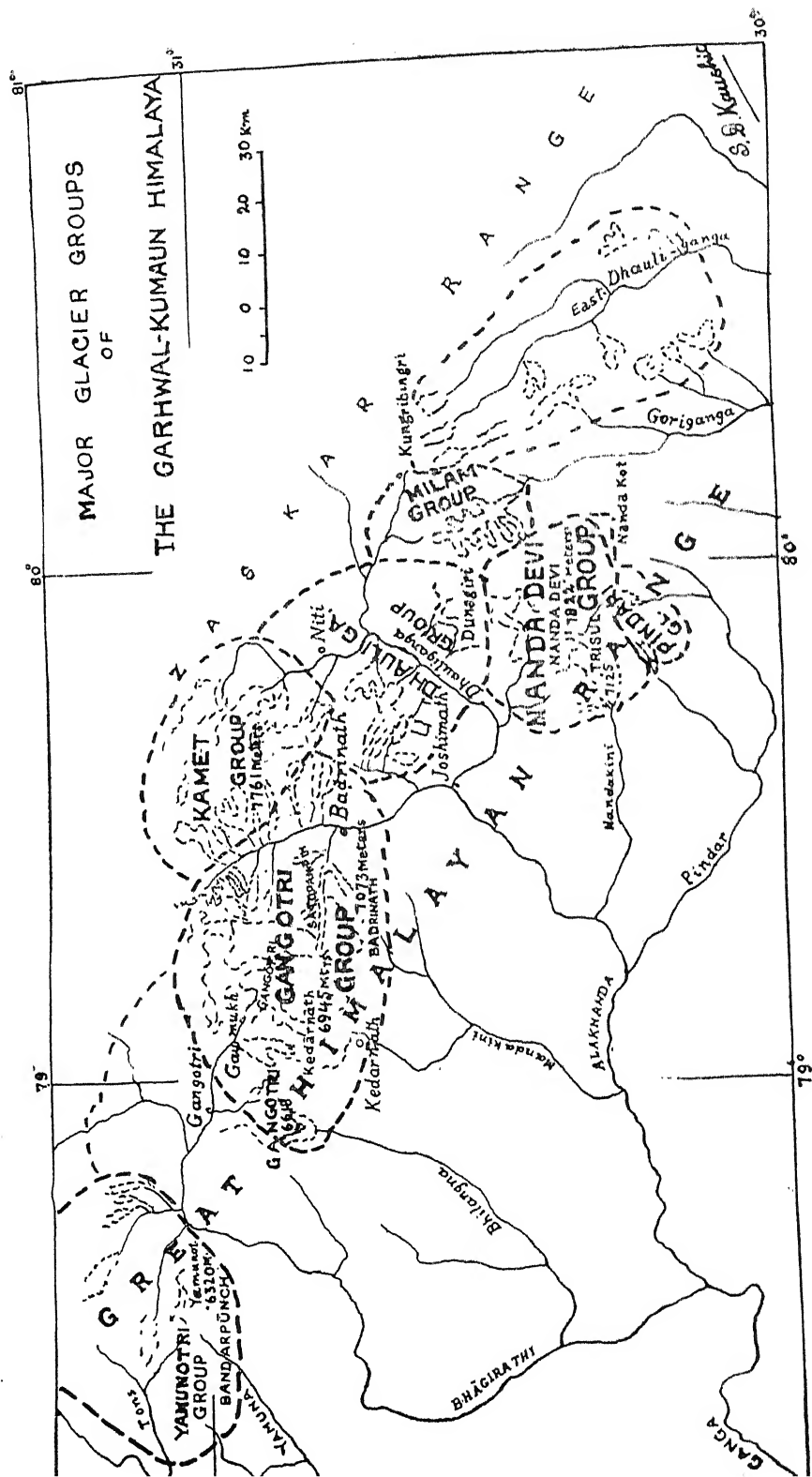
Fig. 1. Glacier-groups of the Garhwal-Kumaun Himalaya.

(3) The Kamet group includes East Kamet, West Kamet and Raikana glaciers.

(4) The Dhauli Ganga group has glaciers on the east and west, both the sides of the valley. Dunagiri, Changbang, Bagini, Uja Tirche, Girthi, Hoti, and Niti glaciers are on the east of the Dhauli Ganga ; while Kankal Bank, Kosa and Banke glaciers are on the west of it.

(5) Nanda Devi, 7801 meters (25,645 ft.), is the highest peak in Garhwal-Kumaun Himalaya. The main glaciers of this group are the Nanda Devi, Trisuli, Kurumtoli, Nandakana, Betatoli and Rahmani.

(6) The melt of Pindari and Sukeram glaciers feeds the Pindar river, which is a tributary of the Alaknanda. Of these, the Pindari has an easy approach, as it lies at comparatively lower altitudes (below 4,000 meters).

(7) Milam and (8) Panchu glaciers occupy the source regions of the Gori Ganga and Kali river. Milam is also easily accessible.

Snowline :

There are two altitudinal zones of ice : (i) perennial, and (ii) fluctuating. The snow-cover on the ridges is not uniformly thick, because the snow creeps down the slopes, and accumulates in the hollows, troughs and valleys. The accumulated snow converts into ice by crystal growth under the pressure of successive layers of snow at the surface. The lower layers of snow melt, refreeze and compact, forming ice crystals. Then, thick masses of ice move as glaciers. In several valleys, in this region, the glaciers extend below the snowline, e.g. Rishi Ganga glacier, and Kosa glacier of Dhuali Ganga Zone, and Badrinath glacier of the Alaknanda Zone.

In Garhwal and Kumaun, the southern slopes of the Great Himalayan Range have the perpetual snowline along the Nanda Devi group, Pindari-Milam groups, and Gangotri-Yamunotri groups at about 1,200 meters (4,000 ft.) lower than the Kamet group in the rear of the Great Range. The mean altitude of the Gangotri glacier is about 4,200 meters (14,000 ft.) and of the Satopanth glaciers is 4,500 meters (15,000 ft.) above mean sea level. The Pindari glacier lies between 3,600 and 4,000 meters.

Length of some important glaciers :

The important glaciers of this region are 12 to 30 km. long. Their approximate lengths are :

1.	North Nanda Devi glacier	... 19 km.
2.	South Nanda Devi glacier	... 19 km.
3.	Bagini glacier	... 16 km.
4.	Kosa glacier	... 11 km.
5.	Satopanth glacier	... 12 km.
6.	Bhagat Kharak glacier	... 20 km.
7.	Gangotri glacier	... 20 km.
8.	Kedarnath glacier	... 12 km.
9.	Mana glacier	... 20 km.
10.	Milam glacier	... 20 km.

Climatological study of the glaciated zone :

In this region of high altitudes, there is one summer seasonal meteorological observatory at Badrinath, which, however, does not supply data related to the

winter months. Records of the Himalayan climbing parties and expeditions also contain information about the temperature conditions, winds, snowfall, etc., at different altitudes, on different dates ; but, they also do not give any figures related to winter months. Only rough estimates of snowfall, during each winter, in the Himalayan valleys are made by the Meteorology department.

In the areas above 3,900 meters (13,000 ft.), there is snowfall not only in winter, but also in April, May and June, from the western depressions. Both the winter and spring precipitations decrease from west to east. However, the two vast zones of glacierisation (Bhagirathi-Satopanth group and the Nanda Devi group) need a detailed and scientific study of the meteorological conditions throughout the year, for several years. The author has noted that the night temperatures even during the summer months of May and June fall below 4°C. In the daytime, on account of rarefied atmosphere, the sunshine is felt to be scorching ; but the wind velocity on the high altitudes is very high, and there are blizzards sometimes of the velocity of about 150 km. per hour. The average amount of annual snowfall is about 450 cms. in the western part and about 400 cms. in the eastern part of this region.

Antecedent troughs and consequent troughs of the Himalayan glaciers :

There are two types of troughs occupied by the existing glaciers. (i) The glaciers forming the source regions of the Jad Ganga (Jahnavi), Bhagirathi, Alaknanda, Saraswati and Dhauli Ganga occupy antecedent troughs. During the Pleistocene glacial age, these glaciers descended down into these antecedent valleys upto 2000 meters' altitudes. The valleys of these antecedent rivers belong to an age anterior to the uplift of the Himalayan ranges ; and during the Pleistocene Ice Age, their upper reaches were occupied by glaciers. In the Recent and Sub-Recent periods the glaciers have retreated on account of ablation. The antecedent drainage has survived the mountain uplift, and have maintained their channels athwart the axis of uplift.

(ii) Consequent troughs are occupied by those glaciers which lie at the sources of the consequent valleys, e.g. those of Rishi Ganga, Kosa, Nandakini, Birehi, etc. Their streams are the tributaries to the antecedent rivers, although some of these tributaries too have carved very deep gorges. The Rishi Ganga has carved a most terrific gorge, which is yet unscanned by man.

Mechanism of melt-water :

The physical and mechanical action of melt-water plays an important role in the morphosis and movement of a glacier. Its two important functions are (i) to exert the expansive force after refreezing, and (ii) to lubricate the ice in its movement on the valley floor.

The upper surface of a glacier consists of comparatively soft snow and ice ; the middle strata are composed of granular ice, while the lower layers are fully compact. On account of the heavy load of accumulating snow-cover on the surface, the snow crystals in lower layers become partially melted. This melt water trickles down and refreezes into grains of ice. In the bottom layer, the ice is so compact, that the percolation of even a slight quantity of water between the grains and its instantaneous freezing would cause an expansion of ice and movement of the glacier.

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SURFACE  LAYER        SOFT  SNOW
GRANULAR  SNOW     MELT  WATER  TRICKLES  DOWN
NEVE    GRANULAR  ICE    MELT  REFREEZES
                        INTO  GRANULES
BOTTOM  LAYER      ICE    EXPANSIVE FORCE OF
                        FREEZED  MELT-WATER
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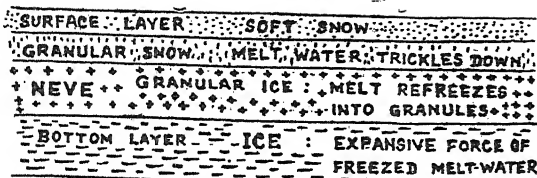
Fig. 2. Composition of the different strata of a glacier, and the mechanism of melta-water within it. (The vertical scale in the surface layer is highly exaggerated).

In the Narayan Parbat glacier, Kedarnath glaciers, and others, there are observed shears of ice over stagnant ice, in summer. These shears are formed by the expansive force of ice in its granular growth.

Because of this melt-water mechanism, many glaciers have a faster movement in summer than in winter, particularly some of those glaciers that are occupying south-facing troughs, *e g* Arwa valley glacier and East Kamet glacier. But, it is not a rule, and there are other factors too, which govern the rate of glacial movement.

Glacial movement :

Glacial movement is a 'solid flow' because of the orderly molecular rearrangement in a glacial advance or retreat. The ice being a brittle solid, its movement is accompanied by the formation of folds, shear zones, faults and crevasses in the body of a glacier.

The diurnal and periodical movement of the glaciers differs from zone to zone. The rate of advance or retreat does not depend merely on climatic changes and gravity. The following factors control the glacial movements :

(1) Temperature changes, which affect the amount of snowfall, thaw and evaporation.

(2) Aspect of the slope (sunny or shady) : the total amount of insolation received by a glacial valley or trough is governed by the aspect.

(3) Mass of ice and snow : winter season has a greater mass of snow and ice than the summer ; still, the glaciers are observed to move faster in summer, because of the action of melt-water. However, the total amount of ice contained in a glacier affects its movement. Long glaciers usually move faster than the shorter ones.

(4) Shape of the glacier.

(5) Degree and gradient of the slope.

(6) Relief of the valley floor, and the surrounding topography.

(7) Slope of the upper surface of the ice.

(8) Wind masses and clarity of the sky, affecting the amount of snowfall and thaw.

(9) Crustal mobility, tectonic tremors, and seismic influences.

It has been noted that there is no periodic regularity of advance or retreat of glaciers related with the weather cycles. There are intermittent oscillations and advances. The usual tendency of the Satopanth group and Kedarnath group

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glaciers is to move faster in summer than in winter ; but, reversals to this tendency are also seen in several years, *e.g.* in 1951 and 1952 in the case of the Badrinath group.

Even in the same glacier, the rate of movement differs from snout to the middle part, and from the bottom to the top. Such observations were made in the Narayan Parbat glaciers. The bottom and lateral parts of a glacier are checked in their movement by the friction against the rocks of the trough. Therefore, the sides and bottom have a lower rate of movement than the top surface and the middle part. If for eight-to-ten or more years, the climate undergoes a bit cooler phase, with a reduced melting and evaporation at the snout, then there may occur a periodic or accidental advance in the glaciers.

The diurnal movement of Badrinath and Kedarnath glaciers is about 10 to 15 cm. In other groups, it ranges between 10 cm and one meter.

In those glacier valleys, which have undergone a tectonic movement, superficial and surface moraine keeps the snout and front-ice hidden for one or two km.
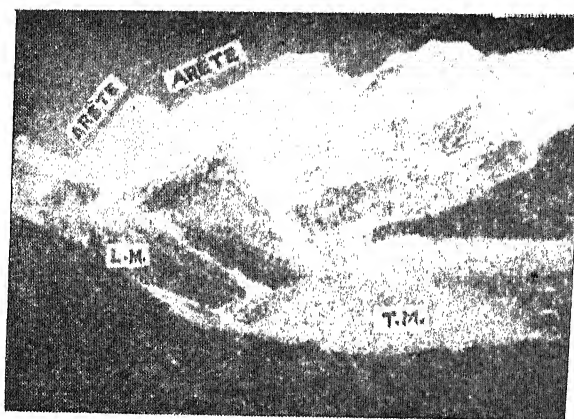
Fig. 3. Eastern Kedarnath glacier, which has rapidly moved back, consequent upon a tectonic movement in the uppermost valley of the Mandakini. The latter has rejuvenated ; and the glacier has got retreatingly concealed under the huge morainic debris at the snout, in Recent and Sub-Recent periods.

(*Photo by Kaushic*)

T.M. — Terminal Moraine.
L. M. — Lateral Moraine.

Glacial topography :

The salient features of the glacial topography, in this region, are as follows :

The erosional features are the cirques (simple and compound), U–shaped valleys, truncated spurs, aretes, pyramidal peaks and horn peaks, serrated crests of ridges, striated and grooved rock surfaces, roche moutonnces, hanging valleys, waterfalls, cols, rock basins, and glacial peat bogs. They are exemplified in the sequel.

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Cicques.—These are valley heads of the glaciers. The niches occupied by snowbanks are gradually excavated by the headward erosion of ice, by sapping and frost action. These are mostly amphitheatre-like depressions at the heads of the glaciers. They have steep walls on three sides, and on one side there is an open outlet for the glacier. The size of a cirque depends on the snowbanks which feed the glaciers. Most of the cirques of this region are compound ones.
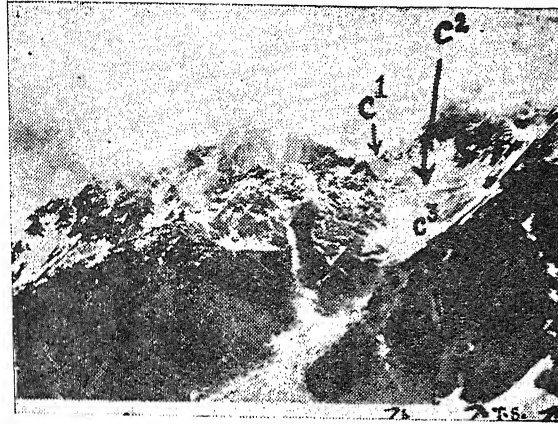
Fig. 4. A compound cirque (C_1, C^2 and C^3) in .the right-half of the landscape, and cascading glacier in the centre. A headward glacial erosion by another cirque is partly visible in the right-hand bottom cornor, in Narayan Parbat, above Vasudhara. (*Photo by Kaushic*)

T.S. — Truncated spur.

In Chawkhamba, Nilkantha, Trisul, Nanda Devi, Duna Giri, Kedarnath and Gangotri glaciers there are compound cirques. Nivation takes place around the lower edges of the permanent snowbanks. Winter freezing and summer thawing cause the snow margin to advance or retreat many meters. On a smaller scale, the same process takes place during night and day. The rocks disinte‧grated by this section are removed down, and the cirques are deepened and widened.

U–shaped valleys.—Glaciers move with their lateral, terminal and ground moraines. This morainic matter consists of boulders, rock pieces, stones, gravel, sand, etc. ; and it possesses a great chiselling force of powerful tools. When a million-ton heavy glacial stream, equipped with an enormous load of erosive tools, impinges against the walls and bottom of its valley, it overwhelms and erodes away all the rock obstackles. The banks of the trough are grooved, scoured, rubbed and polished ; and the glacier valley assumes a U‧shape, which is different from the V‧valley of a river.
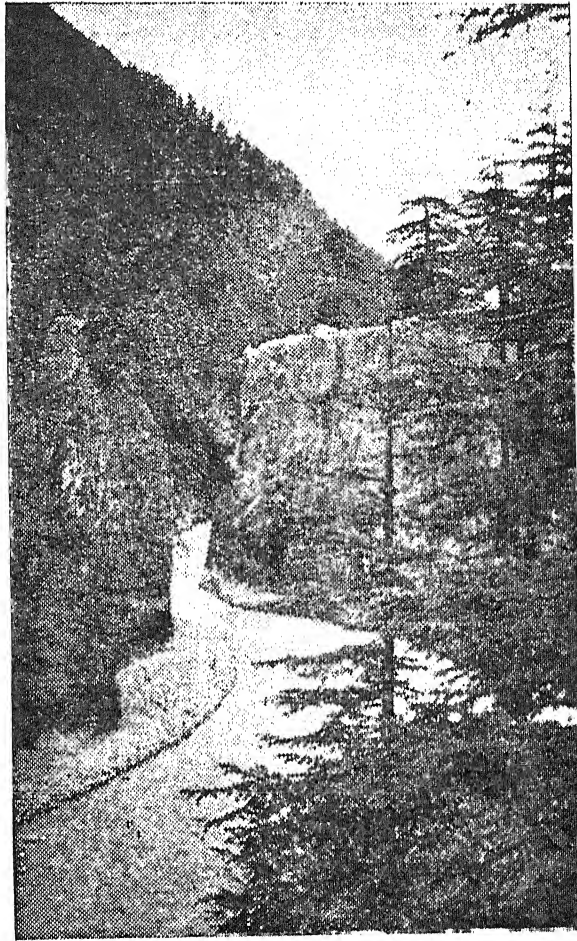
Fig. 5.   A typical example of the U-shaped valley of a glacier : the Bhagirathi gorge at Bhaironghat.   It was carved in hard granitic rocks by the Gangotri glacier, which has now retreated by ablation.   Now, the river flows in the glacial trough.

(Photo by Kaushic)

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Truncated spurs.—The lateral moraine, by its constant and continuous erosive force, wears away the solid rocks and parts of spurs projecting into the valley. Truncated spurs are cheif features indicating the tremendous erosive force of a glacier, The spurs lying between the tributaries of a main valley, have '*faceted*' ends of triangular shape. Alaknanda, Gangotri, Mandakini, Dunagiri and Nandakini (Trisul) glaciers, all have truncated spurs in their troughs.
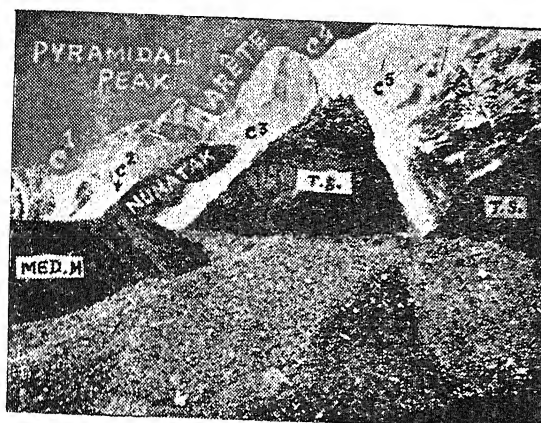
Fig. 6. Truncated spurs (with faceted ends of triangular shape), aretes, nunataks. and peaks formed by glacial erosion, in the Eastern and Western glaciers of Kedarnath group.   (*Photo by Kaushic*).

T. S. — Truncated Spur
Med.M. — Medial moraine.

Nunataks.—These are rock masses surrounded by ice. A nunatak stands between two valley glaciers or two lobes of ice sheets. It appears to be an island in the mass of ice. It is gradually worn away by the lateral erosion and frost action accompanied by avalanches. Nunataks are existent in all the glaciers of this region (Fig. 6.).

Aretes.—These are knife-edged sharp ridges, formed by glacial sculpture. They are the products of the continuity of cirque erosion on both the sides of ridges. They are common features througout the glaciated tracts. (Fig. 6).

Serrated ridges.—They are common above 4,800 meters (16,000 ft.), in the Gangotri, Satopanth, Kamet, Narayan Parbat glacier, and Nanda Devi zone. The Alkapuri Range, covered with silver-white snow in the Satopanth area, presents one of the most beautiful ridges in the world.

Headward erosion or cirque recession on the two sides of a ridge goes on thinning the ridge tops, and the divides are eroded away. Also by frost action and gravity, rocks of the narrow divides fall off, and the topography presents a saw-toothed ridge.

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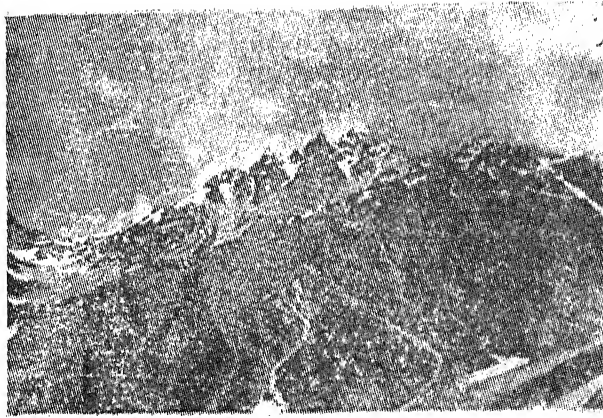
Fig. 7   A serrated ridge in the Narayan Parbat, above Vasudhara falls. Note the melt-water flowing through a cave, formed in the morainic debris.   (*Photo by Kaushic*).
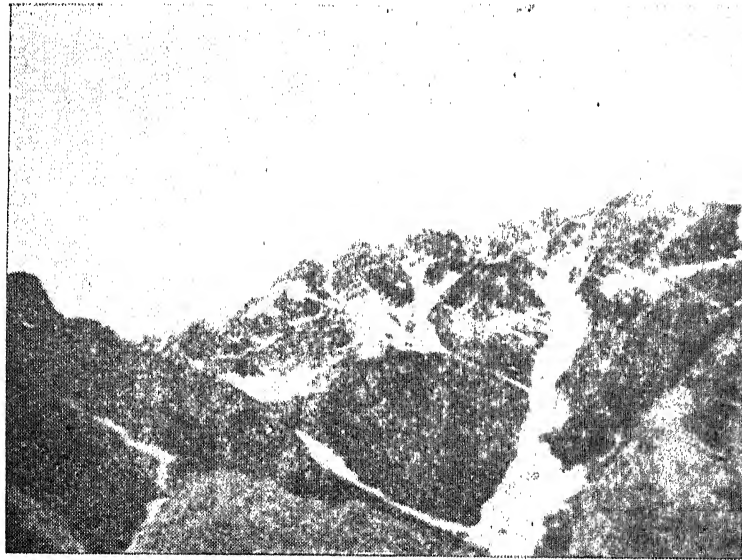
Fig. 8.   A valley glacier with two cascading tributary glaciers, and the serrated crest of ridge, in Badrinath group of glaciers.   (*Photo by Kaushic*).

Pyramidal Horn peaks :

Most of the peaks in these glacial tracts are pyramidal horn peaks.   Their formation is due to the headward recession of three or more cirques around a peak. These peaks have sharp sides with sharp points at the top.   Hornpeaks rising above 6,000 meters (20,000 ft.) are the most dominating feature. Satopanth, Shival-ing, Nilkantha, Shrikhanda, Chowkhamba and Sumer Peaks are typical examples of pyramidal peaks, each one of which is larger than the Matterhorn Peak of the Alps.
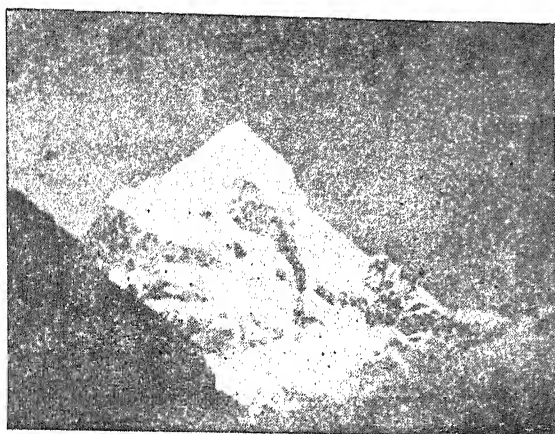
Fig. 9. Nilkantha Peak in the Satopanth Zone. It is more than 3 times massive as compared to the Matterhorn Peak of the Alps. It is sculptured by cirque-recession and lateral enlargement. which narrows and sharpens the central residual mass. The peak is yet unclimbed by man. *(Photo by Kaushic)*.

Roche Moutonnees.—They lie scattered at many places in each of the glacier zones of this region. Their presence at lower altitudes, about 2,000 meters (6,600 ft.), is a proof of the existence of Pleistocene glaciers upto that level. In the Bhagirathi valley, such knubs of striated, grooved and polished rocks are seen down the source upto Dharali, Harsil and Sukhi. In the Alaknanda valley, they are present upto Pandukeshwar and a bit below. In the Kedarnath glacier valley of the Mandakini, the roche moutonnees are seen to exist upto Munkat Ganesh. The onset-ends of these rocks have smooth slopes, which are polished by the impinging force of ice, while their lee-ends are steep and hackly, according to structure and joint-pattern of rocks. However, on the lee sides, blocks are detached by plucking, and rolled forward by moving ice. Glacial erosion polishes the mountain slopes, and carves a 'biscuit board' topography, in which some cirques remain hanging, and some troughs are only partly formed by headward erosion of melt-water streams.
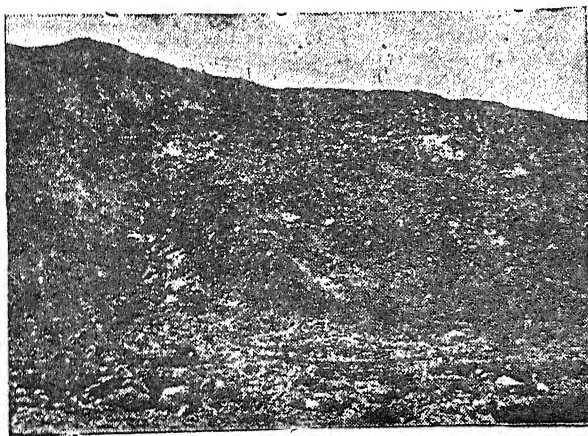
Fig. 10. Glacially polished slopes in the Narayan Parbat, in Satopanth Glacier Zone. *(Photo by Kaushic)*.

Hanging Valleys :

Many of these glaciers have got their tributary glaciers. After the melting of ice, the tributary valleys remain hanging high above the main channel, because those tributaries do not possess enough mass of ice to erode their valleys effectively down to the level of the main channels. Waterfalls exist at the mouths of these tributary valleys. There are several hanging valleys in each of the Bhagirathi, Alaknanda, Mandakini and the Dhauli Ganga valleys.

Fig. 11. Hanging Valley of the Vasudhara Falls. The Satopanth glacier, which occupied the main valley in the Pleistocene age, has retreated by ablation, and the tributary valley of the Vasudhara remains hanging. There is a fall of about 450 meters (1,500 ft.).

(*Photo by Kaushic*)

Floods caused by glacial erosion :

At the snouts of several glaciers of this region, the englacial and subglacial moraines have joined the terminal moraines. The enormous debris appears to have choked the ice-tongue. In every summer, the surface ice of glaciers melts by insolation ; and in the rainy season the rate of thaw is highly accelerated by the mechanical and solvent action of rainwater. Melt-water flows down the crevasses and grooves. An englacial river of the melt flows through a subglacial tunnel. It is checked by the enormous dam of terminal moraine. Accidentally, in any year, such a dam is broken away by the melt-water, and it results in a heavy flood.

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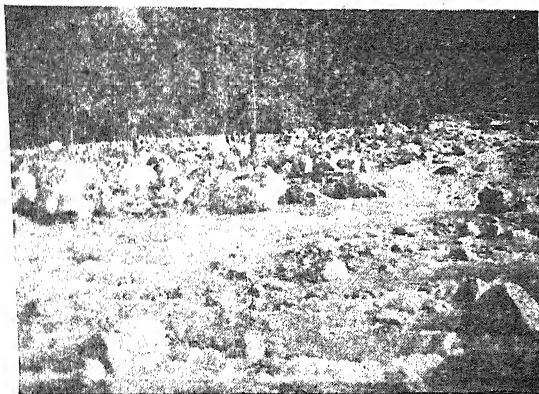
Fig. 12.   Old site of village Harsil, which was swept away by a flood in the Jalandhari
Ganga (a tributary of the Bhagirathi), caused by an accidental break of the
morainic dam of the Jalandhari glacier.   *(Photo by Kaushic)*.

Deposional features :

The chief deposional features of glacial topography, in this region, are the
tillite ridges, talus cones, debris deposited by terminal moraine, lateral moraine,
medial moraine, ground moraine and surface cover moraine, boulders, erratics,
eskers, snow-bridges, dead ice, and bogs.   They are exemplified in the sequel.

There are glaciated pavements in the granitic zone, in the upper parts of
the Bhagirathi, Jad Ganga, Saraswati, Alaknanda and Mahdakini valleys.   Old
high level moraines indicate the height to which these glaciers had once risen.
There exists a bank of about 120 meters (400 ft.) high deposit of lateral moraine
above the snout of the Gangotri glacier.
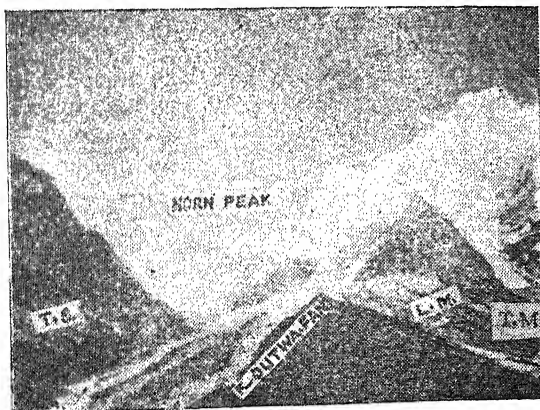
Fig. 13.   Morainic Deposits of the West Kedarnath glacier.
T.M.—The terminal moraine ; L.M.—Lateral Moraine ; OUTWA.FAN—Out-wash fan ;
T.S.—Truncated Spur ; B.R. S.T.—Braided streams of melt-water.   *(Photo by Kaushic)*.

Deposits by the terminal moraines are crescent-shaped transverse ridges.   In
the main valleys of the Bhagirathi, Alaknanda, Saraswati and Dhauli Ganga, the
Pleistocene terminal moraines have been washed away by the torrential streams of
these rivers.   The Recent and Sub-Recent morains ramain deposited in outskirts
of the present glaciers.
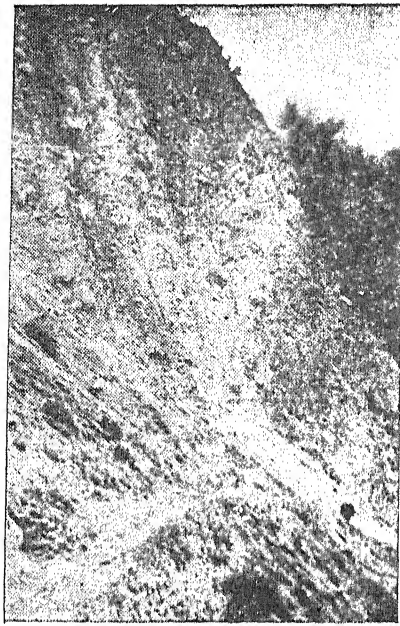
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Outwash fans have been deposited in the upper courses of these glacial valleys, by the outflow streams (Fig. 11).

Boulders.—Glacial boulders of various sizes occur scattered all over the glaciated tracts in this region ; some of them are very massive, being larger than elephants, and some are small. Where melt-water or rainwater enters the joints of rocks, it freezes, and expands to break the rocks. Gravity pulls the disintegrated rocks onto the glacier surface. Boulders are also detached by frost action and gravity. Snowslides and avalanches as well bring down waste material onto the surface of the glaciers. The moving ice transports these boulders and deposits them on the valley floor. The chief feature of these glaciated boulders is that they are well polished, grooved and striated.

Fig. 15. Striated and polished boulders remaining perched on the polished bank-wall of Bhagirathi gorge, below Gangotri, near Bhaironghat.

(*Photo by Kaushic*)

Due to the rejuvenation of the Himalayan valleys, the Pleistocene glacial troughs have got uplifted, and their floors are over-strewn with the glacial boulders of that age. Such examples are those of the high altitude pastures (above 2,400 meters) of Bhagirathi valley from Harsil to Mukhba, of the Alaknanda valley from Pandukeshwar to Mana, of the Mandakini valley from Rambara to Kedarnath, and of the Dhauli valley from Gamsali upwards.

Fig. 16. Glacial boulders strewn over the Pleistocene glacial trough of the Gangotri glacier, above Harsil and below Dharali. *(Photo by Kaushic).*

Tillite fan.—Debris consisting of unassorted coarse and fine material is deposited by tributary glacial streams in the form of fans, at the bases of ridges or on the banks of the main channel. This debris is called till, which is usually angular ; but, if it is brought by melt-streams to far distances, it gets rounded.
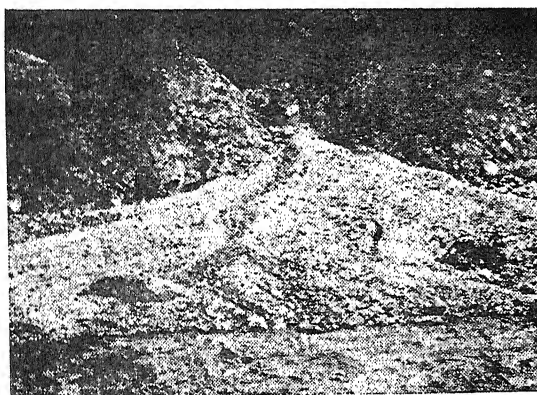
Fig. 17. A tillite talus fan deposited by the melt-water stream, from a tributary glacier, in the Gangotri zone. The fan is deposited in the upper reaches of the Bhagirathi channel, between Gangotri and Gau-Muk. *(Photo by Kaushic)*

Tillite ridges.—Tremendous mass of moraine is deposited in the form of tillite ridges, some of which are more than 300 meters (1,000 ft.) high. They consist of unstratified, unassorted, mixed debris of every size from clay to huge boulders. They represent a sudden change of topography as well as in the rate of ablation, in the stage and history of a glacier. Interesting examples of such tillite ridges are those of the Sutol Pastures below the Trisul glacier, of the Nar Parbat 'Bugyal' pastures (above 3300 meters : 11,000 ft.) of the Bhagat Kharak glacier, of Hanuman Chatti ridge in the Alaknanda valley, etc.

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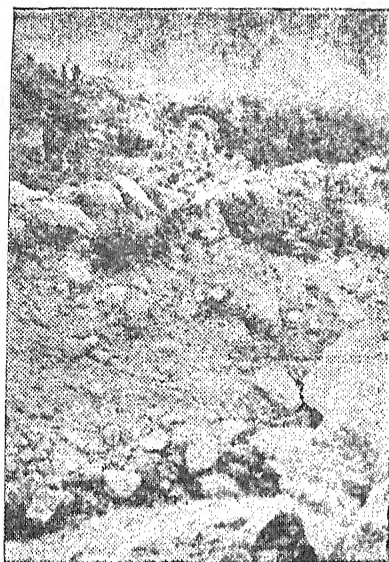
Fig. 18. A tillite Ridge of Pleistocene age, in the Alaknanda zone, between Hanumanchatti and Deo-Dekhni. (*Photo by Kaushic*).

Dead Ice—Glacial-deposition consists of not only the detrital matter and rock waste, but also stagnant ice. Colossal parts of the ice-front get detached from the main glacier, by tectonic movements or earthquake tremors, which cause the ice-mass to break off along some crevasse or shear-plane or fault-plane. The detached ice-mass remains rested in any synclinal basin or depression on the ground. It continues to lie as stagnant ice and decreases by slow ablation. It receives accumulations of snow from the winter precipitation, and it undergoes thawing and evaporation during summer. In some places, such masses of dead ice are existing as bridges over the head-streams of Alaknanda, Arva, and other valleys.

Fig. 19. Dead ice, existing as a bride over the head-stream of the Alaknanda, below the Satopanth glacier zone. It leads from the Vasudhara Falls tract to the Narayan Parbat and Nilkantha tract. (*Photo by Kaushic*)

Eskers consisting of gravel and sand have deposited by glacial melt-water streams. These long narrow ridges are composed of somewhat stratified sand, silt and gravel. In the area between Narayan Parbat and Chakra-Tirtha of Satopanth glacier, there are quite long eskers, where stagnated ice disappeared by melting in situ, and also at those places where the glaciers regularly discharge melt-waters from their fronts in other glacier zones (*e.g.* in the Mandakini glacier zone).

Fig. 20.   An Esker on the left side of the landscape, and the outwash plain of the Pleisto-cene and Recent age of the Satopanth glacier; above the Vasudhara Falls. The glacier has retreated in the the Sub-Recent period.   (*Photo by Kaushic*).

Ablation in the Recent and Sub-Recent Ages :

Besides the present glacier troughs, there are old glacial troughs, from which the glaciers have retreated in the Recent and Sub-Recent periods *e.g.* near Mana above Badrinath, above Chakra-Tirtha in the Nilkantha tract, and above Rambara in the Kedarnath glacier tract. All these old glacier troughs are U-shaped valleys, having flat floors and steep banks.
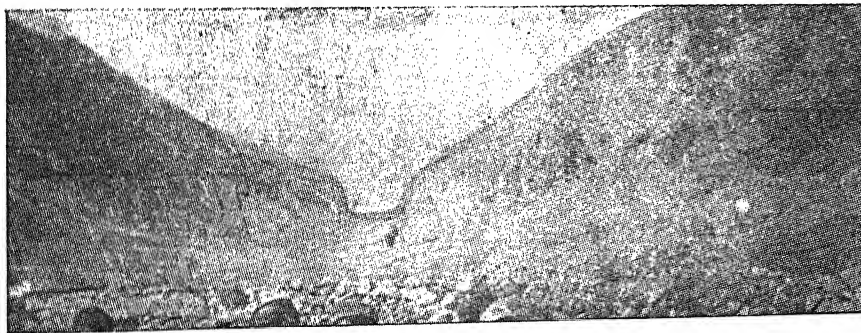
Fig. 21.   An old trough of a retreated glacier : a Col, in Mana Valley. In cross section, the col is outlined by hyperbolic curve. This col was widened and deepened by a transverse glacier in the Pleistocene age. Afterwards the glacier has melted away by ablation in Recent age.   (*Photo by Kaushic.*)
Note the till platform.

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Examples of retreat of glaciers in the post-Pleistocene period.

Name of the glacier	Pleistocene depositional and erosional features are present, at lower levels upto :	Present snout at :
1. Gangotri glacier	Sukhi, below Harsil (2,100 meters)	Gau Mukh, above Gangotri (4,200 meters)
2. Kedarnath Glacier	Munkat Ganesh, in the Mandakini valley (1,950 meters)	Above Chora Bari Tal, (4,500 meters).
3. Satopanth glacier	Hanuman Chatti, below Badrinath, in the Alaknanda valley. (2,150 meters)	Above Vasudhara Falls, in Chowkhamba zone, (4,500 meters)
4. Rishi Ganga glacier	Upto Tapoban. (2,200 meters)	Above Lata, (4,200 meters).
5. Trisul glacier	Wan Bugyal (2,200 meters)	Present source of the Nandakini, in the foot-zone of Trisul Peak. (4,800 meters.)

Sub-cycles of ablation :

Deposits of unstratified till (rock fragments of all sizes) deposited directly by glaciers, and stratified deposits by subsequent fluvial transport, indicate that there have been sub-cycles of ablation, in which these glaciers have advanced and retreated. Dainelli[1] thought that there had been four main glaciations in the Western Himalayas, which could correspond to the Alpine Mindel, Riss, Wurm, and post-Wurm I. H. de Terra[2] also noted the sequence in the Kashmir Himalaya, but he dated these successive periods earlier than Dianelli did. The present author has noted four successive phases in the Mandakini glacier valley, and five successive phases of retreat and advance of glaciers in the Satopanth-Alaknanda zone. He proposes to take up this aspect in a separate paper.

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CYTOCHEMISTRY OF THE MALE ACCESSORY GLAND CELLS OF *HALYS DENTATUS* (HEMIPTERA : HETEROPTERA)

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Introduction

Most insects are equipped with accessory glands in both sexes, which are held to perform some accessory functions related to the reproductive processes. In the bug, *Halys dentatus*, these glands are impressively well-developed, which in itself would seem to suggest their participation in some vital activity of the organism. This work was undertaken to investigate the secretory activity of their cells by means of the more precise techniques of cytochemistry, besides the routine cytological methods.

Material and Methods

Specimens of *Hayls dentatus* were collected from groves at Allahabad during the months October—May and were sacrificed immediately on being brought to the laboratory. The accessory glands of male specimens were extirpated and variously processed. For the demonstration of the Golgi bodies, Weigl's method (with post-osmication at room temperature for three days) was used. For the study of mitochondria the glands were fixed in Flemming's fluid without acetic acid and sections were stained with iron-haematoxyline or acid fuchsin-aurantia.

PAS reaction for carbohydrates was carried out according to the method of Hotchkiss (1948) with and without treatment of the sections with human saliva (for identification of glycogen). For the study of proteinaceous formations the following techniques were used :

(1) Millon's reaction carried out according to Baker's procedure (1956) on formol-fixed paraffin section.

(2) The mercury-bromophenol blue method as employed by Mazia, Brewer and Alfert (1953)

(3) The coupled tetrazonium reaction on formol-fixed paraffin section according to Danielli's (1947) procedure (as given by Pearse, 1960),

(4) The dinitrofluorobenzene reaction on formol-fixed section according to the procedure of Danielli (1950), without blocking treatment with nitrous acid or iodoacetamide,

(5) The ninhydrin reaction carried out by treating formol-fixed paraffin sections with hot ninhydrin,

(6) The xanthoproteic reaction (Pearse, 1960),

(7) The nitroprusside reaction carried out on formol-fixed freezing-microtome sections according to the method employed by Hammett and Chapman (1938),

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(8) The ferric ferricyanide reaction carried out on formol-fixed freezing microtome section according to the procedure adopted by Chèvremont and Fréderic (1943).

For the demonstration of lipoidal material only freezing microtome sections were used. The acid haematin test was carried out on calcium formol-fixed material with pyridine extraction according to Baker's procedure (1946). Staining with a mixture of Sudan III and IV was carried out according to the method of Kay and Whitehead (1941). Sudan Black B (Lison and Dagnelie, 1935) and Nile Blue sulphate (Cain's method, 1947 *a, b*) were also employed. The performic acid Sciff reaction was carried out as suggested by Pearse (1960). The material was also tested for ascorbic acid according to Bourne's technique (1935) and for alkaline phosphatase according to Gomori's method (1946).

Observations

The male accessory glands of *Halys dentatus* consist of a large number of tubules with wide lumina and walls consisting of a single layer of somewhat columnar cells. The PAS-positive material of the cell is organised in the form of an impressive supra-nuclear network and a smaller network in the infranuclear zone facing the lumen of the tubule (figs. 1 & 3). However, the entire PAS-positive material is not included in these formation; there are small grains, cordons and batonetts of similarly reacting material scattered through the cytoplasm. Prolonged digestion with human saliva, lasting over half an hour, has no effect on these bodies and, so, glycogen may be safely considered to be excluded. Phospholipids and unsaturated lipids are located in the infranuclear zone alone (as described below) and never in the supra-nuclear area. The PAS-positive material consists, it appears, of polysaccharides alone (not including glycogen).

The Golgi bodies, as revealed by Weigl's technique, occur in the post-nuclear area as two or three dictyosomes which may form a network (fig. 11). Comparison of PAS and Golgi preparations makes it clear that the Golgi bodies react positively to PAS reagents, although the PAS-positive material is not confined to the Golgi zone but occurs elsewhere too. No osmiophil material has been detected in the supra-nuclear area, which is directed towards the external surface of the tubule and which contains the most prominent network of the polysaccharide material.

The phospholipid material of the cell, as demonstrated by Baker's acid haematin test, is located exclusively in the postnuclear zone and occurs at the level of the Golgi substance. The phospholipid material consists of discs and cords which are interconnected to form a reticulum (figs. 7 & 8). As this material stains intense blue following Baker's procedure, it may be safely considered to contain lecithin, cephalin and sphingomyelin (any or all of these) for the other substances listed by Baker (1946) are obviously excluded. Nucleoproteins too may be considered excluded on account of the loss of staining following extraction with pyridine. From this it also follows that there is no protein-bound lipids which would resist the dissolving action of pyridine (Lison, 1953 ; Almeida and Pearse, 1958 ; Pearse, 1960). It is possible that the entire phospholipid content of a cell is not preserved by Baker's formol–calcium fixative as pointed out by Pearse (1960), but there is no question that what is fixed and stained in the cell by this method is phospholipid. Calcium formol-fixed material stained with alcoholic Sudan Black B revealed a somewhat similar reticulum in the same position, stained black (fig. 9). No lightly stained brownish elements were

detected. Staining with Nile Blue sulphate revealed a large number of granules of different sizes scattered throughout the cytoplasm and stained blue (fig. 4). These must be neutral fat droplets. In addition to these there was a large patch corresponding in position to the Sudanophil material, also stained blue. A mixture of Sudan III and Sudan IV, revealed similar granular bodies scattered throughout the cytoplasm but formed elements other than these did not appear in the Golgi zone (fig. 10). The Golgi zone reacts strongly to Millon's reaction and is brilliantly coloured (fig. 5). The structure so stained is markedly reticular in appearance and stands out sharply against the cytoplasmic background, which itself shows a slight uniform colouration. The mitochondria are not revealed by this technique (or by any cytochemical technique employed in this work) probably because of their extreme fineness. In contrast to this, the application of Chèvremont and Fréderic method resulted in uniformly dense colouration of the Golgi zone (fig. 12), which may be taken to indicate the presence of SH-containing proteins in this zone. However, away from this area, in the supra-nuclear zone also, a small brilliantly-stained body was revealed in some cells. Golgi element were never found in this area. Danielli's coupled tetrazonium reaction (which demonstrates tyrosine, histidine and tryptophan—containing proteins) revealed a prominent, thick-meshed, network—like structure which is well differentiated from the cytoplasmic background. This network lies in the zone where the Golgi bodies occur (fig. 6). Ninhydrin, which is thought to react with NH_2 groups to yeild a bluish (or violet) material, did not produce any colouration at all in any part of the cell, whether it was employed on fresh, frozen or paraffin sections. Sakaguchi's technique for arginine, used according to Baker's procedure (1947), did produce reddish-yellow colouration in the Golgi zone, which however, was exceedingly weak and not differentiable from the general cytoplasmic background. This was also our experience with dinitrofluorobenzene, which was used without any attempt to blocking reations simultaneously to eliminate any of the different groups in a protein with which it reacts. It gave a positive reaction but very faint. The lead acetate method for SS- and SH- containing proteins and the nitroprusside method for SH- proteins (Pearse, 1960) gave equally weak reactions at the Golgi level. Although the Golgi zone reacted positively to these different reagents, it was found impossible to make convincing microphotograph of such preparations.

Bromophenol blue stains the Golgi zone positively, but again this area is not sharply differentiated from the rest of the cytoplasmic background, which also reacts positively.

Ascorbic acid granules are concentrated densely in a single patch which appears uniformly black on account of heavy impregnation (fig. 2). An additional, comparatively small, patch is found in some cells. Ascorbic acid is found in the infranuclear zone where the Golgi apparatus is located.

Gomori's cobalt sulphide method (1946) revealed the presence of alkaline phosphatase in the zone of the Golgi apparatus; it did not occur elsewhere in the cytoplasm. In the Golgi zone, the reaction was found to be very weak, possibly on account of low concentration of the enzyme.

No secretory granules have been observed, which is surprising. An equally surprising result was that the mitochondria could not be demonstrated by any of the cytochemical tests for lipids, proteins and carbohydrates. This might be due to the fact that the mitochondria are exceedingly fine structures in these cells and so do not respond to the rather rough procedures of cytochemistry.

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EXPLANATION OF FIGURES

Accessory gland cells of *Halys dentatus*. Approximate magnification separately indicated in each case.

Fig. 1. A single cell showing polysaccharide material forming a large network in the supranuclear zone and smaller figures in the infra-nuclear region facing the lumen. PAS reaction according to the method of Hotchkiss. Counterstained with celestine blue. (X 3000).

Fig. 2. Part of a cell showing vitamin C granules concentrated in two patches, a large and a small, in the infranuclear zone. Bourne's method. (X 3000).

Fig. 3. Part of a transeverse section of an accessory gland tubule showing PAS-positive material in the cells. PAS reaction according to the method of Hotchkiss, counter-stained with celestine blue. (X 600).

Fig. 4. Nile Blue stained material in the post-nuclear zone. The larger body corresponds to the Golgi element, besides which, however there are smaller elements stained with the dye. Frozen sections stained with Nile Blue sulphate according to the method of Cain. (X 800).

Fig. 5. Part of a cell showing a proteinaceous body corresponding to the Golgi element in the infranuclear zone. Millon's reaction according to Baker's procedure. (X 1500).

Fig. 6. Proteinaceous network like body in the infranuclear zone. Tetrazonium reaction according to Danielli's procedure. (X 3000).

Fig. 7 & 8. Lipoidal material forming a large network in the postnuclear zone at the level of the Golgi elements. Baker's acid haematin test. (X 3000).

Fig. 9. Transeverse section of a gland tubule stained with Sudan Black. In some cells the stained material forms a network in the postnuclear zone at the level of the Golgi elements. Frozen section stained according to Baker's method. (X 800).

Fig. 10. Frozen section of an accessory gland tubule stained with a mixture of Sudan III and IV for neutral fats after Kay and Whitehead. Numerous sudanophil granules in all the cells. (X 800).

Fig. 11. Golgi bodies in the post-nuclear zone of a gland cell. Weigl-Kopsch, with three days' post-osmication at room temperature (X 3000).

Fig. 12. A proteinaceous body in the post nuclear zone. Ferricyanide staining according to Chevremont and Frederick. (X 800).
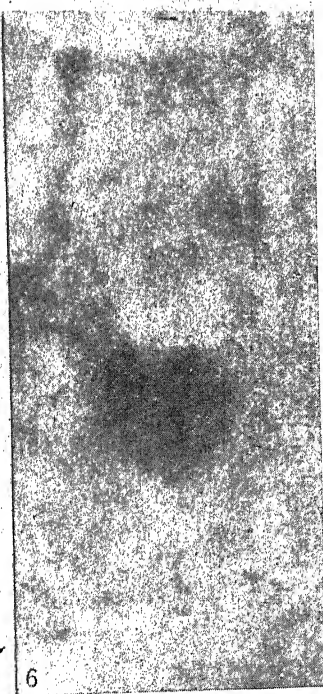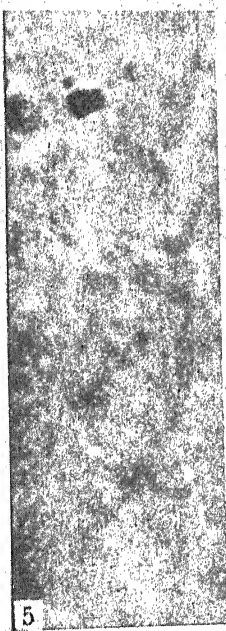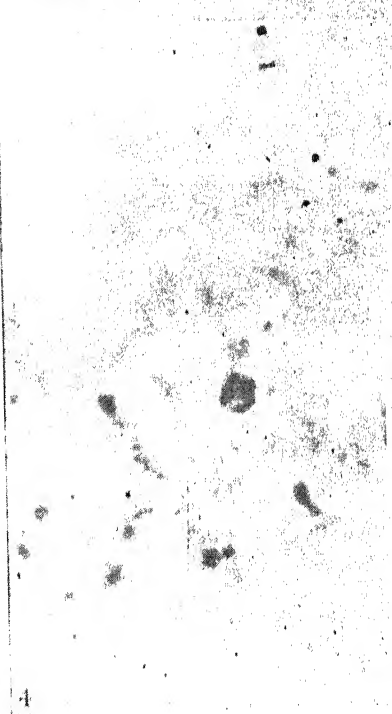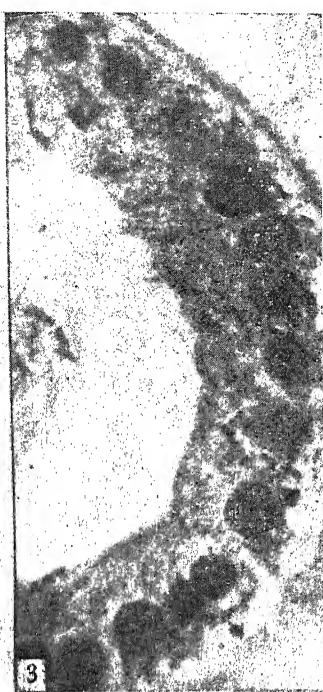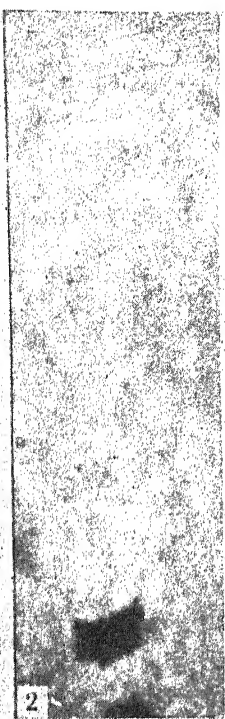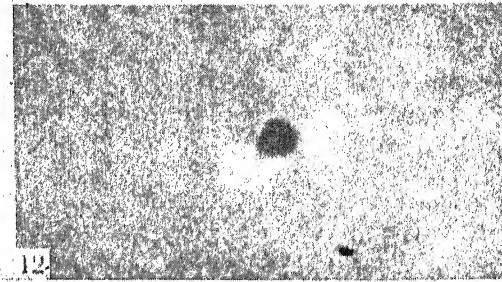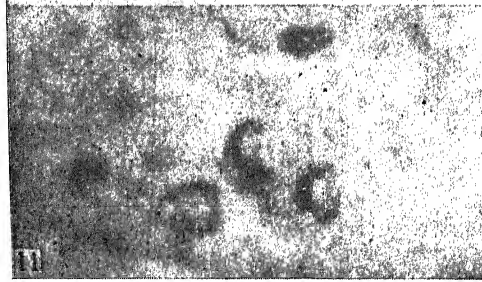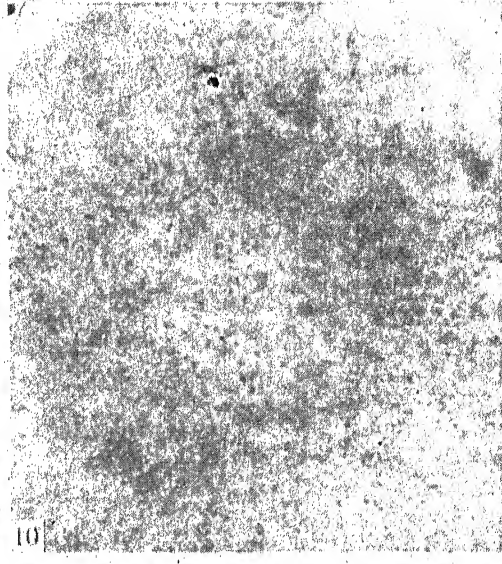
Discussion

Cytochemical tests for lipids, proteins and carbohydrates, besides the usual methods for Golgi elements and mitochondria, have shown that in the cells of the accessory glands of mature specimens of *Halys dentatus* there occur no secretory granules—at least for the greater part of the year. Although structurally this organ has the appearance of a gland, it does not seem to be functioning as such. It may be that this gland remains quiescent during the non-reproductive period and functions only during the breeding season.

It is interesting that in the infranuclear region, in the zone of the Golgi apparatus, occur bodies bearing considerable resemblance to the Golgi apparatus in configuration, but reacting to tests specific for several different substances carbohydrates, lipids, alkaline phosphatase, ascorbic acid and proteins. PAS-positive material seems to be, of a certainty, associated with the Golgi substance, but it is noteworthy that this material is not entirely confined to the Golgi zone, but plenty of it occurs outside this area, and there too it takes on the form of a network.

That the Golgi apparatus contains different proteins, (or at least amino acids), accorbic acid, lipids and alkaline phosphatase in these cells is clearly indicated, but it is also indicated that much of the proteinaceous material lies outside the figure of the Golgi apparatus though confined to the zone where the Golgi apparatus lies. The post-nuclear zone contains an area of highly condensed cytoplasm to which the Golgi appratus and most of the formed proteinaceous and other types of elements are confined. This obviously indicates some special physiological role of this cytoplasmic zone. The mitochondria, which are fine grains and filaments, remain scattered throughout the cell and do not exhibit any marked concentration in the Golgi zone. They never swell and do not show any other indication of participation in secretory function.

That the formed carbohydrate, protein and lipid materials of the cell can take on the form of a reticulum is interesting in view of the controversy regarding the existence and form of the Golgi apparatus (*see* Baker 1950, 1959, 1963). However, it has to be remembered that the cytochemical tests involve fairly gross treatment of the cells, which have got generally to be fixed and stained, and so the correspondence of the form of inclusion in the fixed and living state may not be very close. However, about their location there is no reason to entertain any doubt and one can be reasonably sure that the Golgi apparatus consists of carbohydrates, lipids, proteins, ascorbic acid and alkaline phosphatase. It is unfortunate that the cells of the tubules of this gland are so closely cemented that single cells defy isolation and small lumps of cells that can be isolated, cannot be profitably examined under the phase-contrast microscope. Nevertheless, since preparations made repeatedly by the cytological and cytochemical methods yield practically identical results regarding the location of the cytoplasmic inclusions and of the formed bodies and since there is hardly any variation from cell to cell, worthy of note, the general conclusion regarding the composition of the Golgi material may be considered acceptable in its gross outline.

That polysaccharide material enters into the composition of the Golgi apparatus has been reported by several investigators (Schrader and Leuchtenberger, 1952 ; Leblond and Clermon, 1952 ; Dalton and Felix, 1954 ; Schneider and Kuff, 1954 ; Bradbury and Meek, 1963). The present investigation has shown that the entire polysaccharide content of the cell is not confined to the Golgi material and that a good part of it occurs outside its confines.

That the Golgi element contain proteins has been known since the work of Tarao (1939). In the material studied in the present investigation, protein tests have elicited positive response at the level of the Golgi apparatus.

The association with Golgi apparatus of vitamin C, alkaline phosphatase, and several other enzymes is well known (*see* Bourne and Tewari, 1964).

It is not certain, however, whether in the material investigated, the different proteins, lipids, alkaline phosphatase and vitamin C form an integral part of the Golgi apparatus or whether they occur, to some extent, freely in the post nuclear zone.

The absence of any visible evidence of secretory activity in cells supposed to be secretory in function is a puzzling phenomenon and deserves further enquiry.

Summary

The male accessory-gland cells of the bug, *Halys dentatus*, have been studied by means of the routine cytological techniques for demonstrating the Golgi elements and mitochondria and also by cytochemical techniques employed for the demonstration of proteins, polysaccharides, lipids, vitamin C and alkaline phosphatase. No formed secretory material has been found by means of these methods and altogether there is no clearly visible evidence of secretory activity on part of these cells. PAS-positive material is demonstrated at the level of the Golgi bodies, but it occurs also elsewhere in the cytoplasm. Acid haematin test indicated concentrated lipoidal material in the post nuclear zone at the level of Golgi bodies. Similarly, proteinaceous material and vitamin C granules and alkaline phosphatase occur at the level of Golgi bodies. These proteinaceous, lipoidal, and polysaccharide material form net-works. Mitochondria occur as granules and filaments scattered throughout the cytoplasm.

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